The Open Source Brain Initiative

Enabling collaborative modeling in computational neuroscience

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Lab of Angus Silver
University College London

Model Lifecycles…

How are detailed neuronal models developed at the moment?

Publishing models in computational neuroscience

Spend 1-2 years performing experiments, implementing & tuning model

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Another group starts from scratch because they use a different simulator…

Suggestions for improvements

Record all changes in model after publication

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Allow anyone to comment on/improve model

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Track reuse of model elements between models

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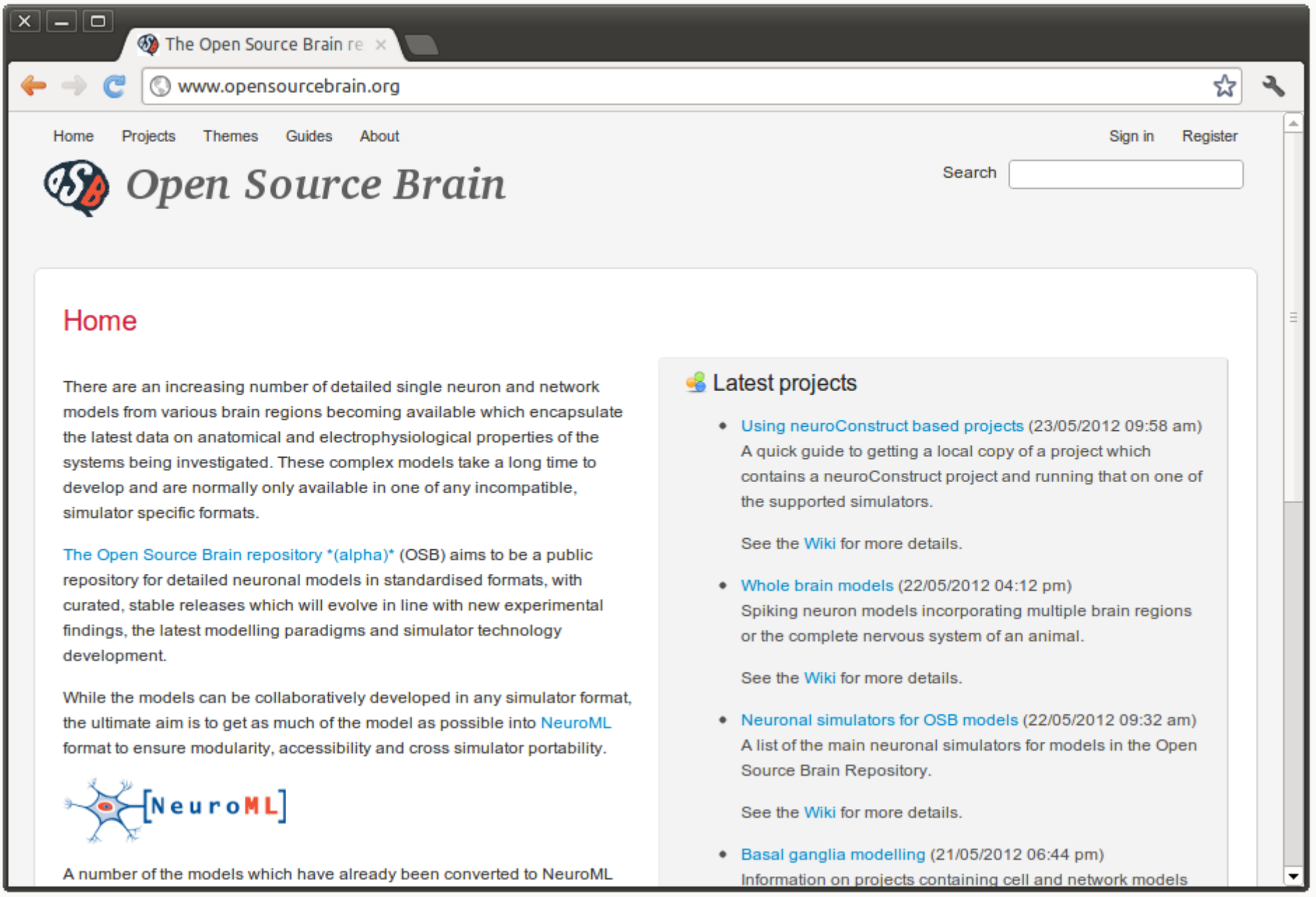
Convert to simulator independent formats

A proposed solution…

The Open Source Brain Initiative


The Open Source Brain re
www.opensourcebrain.org
Home
Projects
Themes
Guides
About
Sign in
Register
Open Source Brain
Search
Home
There are an increasing number of detailed single neuron and network models from various brain regions becoming available which encapsulate the latest data on anatomical and electrophysiological properties of the systems being investigated. These complex models take a long time to develop and are normally only available in one of any incompatible, simulator specific formats.
The Open Source Brain repository *(alpha)* (OSB) aims to be a public repository for detailed neuronal models in standardised formats, with curated, stable releases which will evolve in line with new experimental findings, the latest modelling paradigms and simulator technology development.
While the models can be collaboratively developed in any simulator format, the ultimate aim is to get as much of the model as possible into NeuroML format to ensure modularity, accessibility and cross simulator portability.
NeuroML
A number of the models which have already been converted to NeuroML
Latest projects
Using neuroConstruct based projects (23/05/2012 09:58 am)
A quick guide to getting a local copy of a project which contains a neuroConstruct project and running that on one of the supported simulators.
See the Wiki for more details.
Whole brain models (22/05/2012 04:12 pm)
Spiking neuron models incorporating multiple brain regions or the complete nervous system of an animal.
See the Wiki for more details.
Neuronal simulators for OSB models (22/05/2012 09:32 am)
A list of the main neuronal simulators for models in the Open Source Brain Repository.
See the Wiki for more details.
Basal ganglia modelling (21/05/2012 06:44 pm)
Information on projects containing cell and network models

The Open Source Brain Repository

Wellcome Trust funded project

Collaborative, open source model development repository for computational neuroscience

Structured database of well tested **spiking neuron** & network models in standardised formats

Allow anyone to comment on, extend, reuse models & run them across multiple simulators

Uses tools & best practices from Open Source software development

Enabling technologies

What applications & standards are needed to make this happen?

NeuroML

Standardised XML language for computational neuroscience

NeuroML

Standardised XML language for computational neuroscience

Version 1.x allowed specification of:

- Detailed neuronal morphologies
- Ion channels
- Synapses
- 3D network structure

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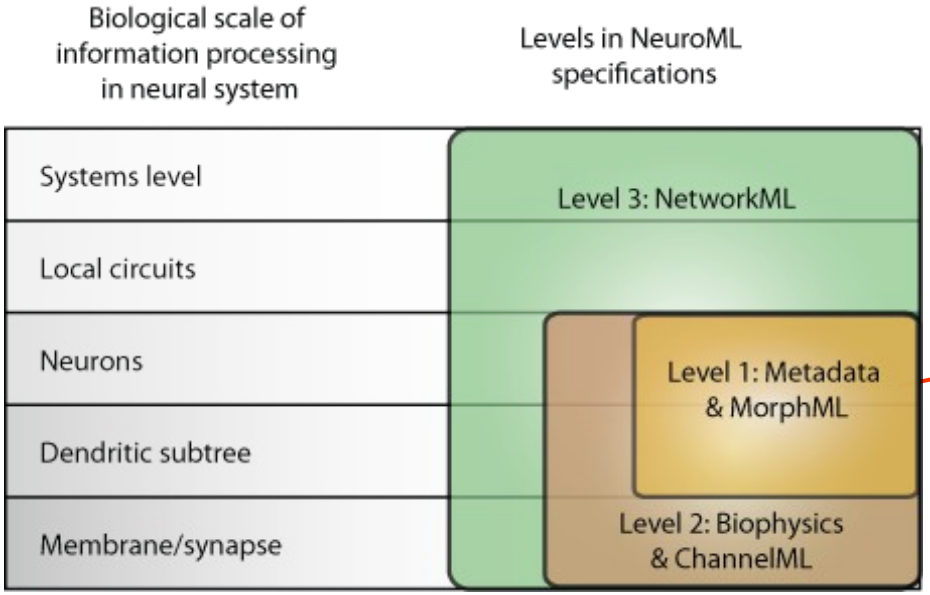
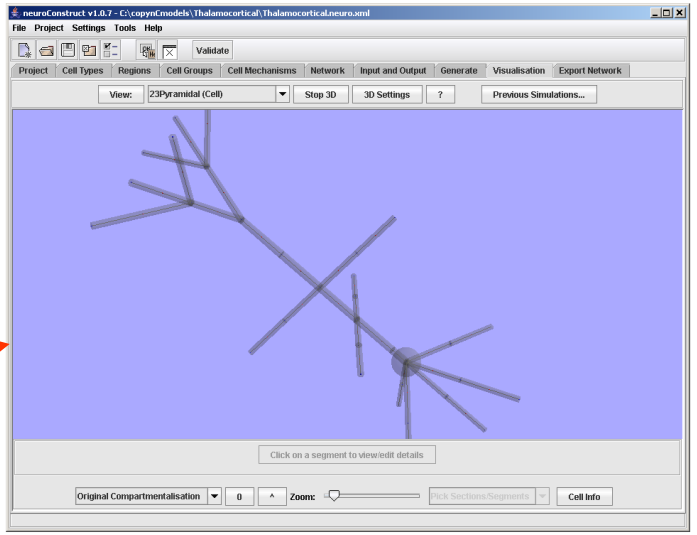
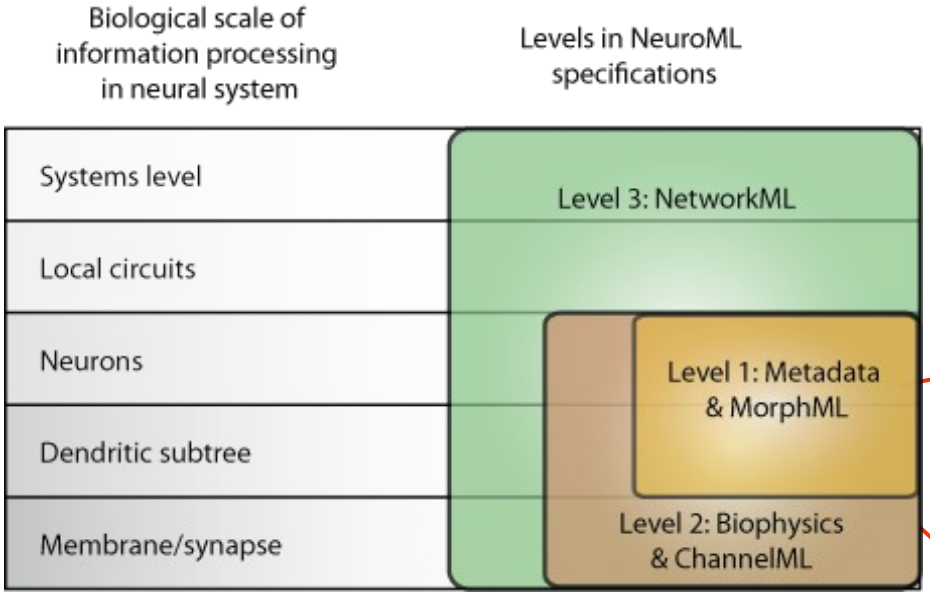
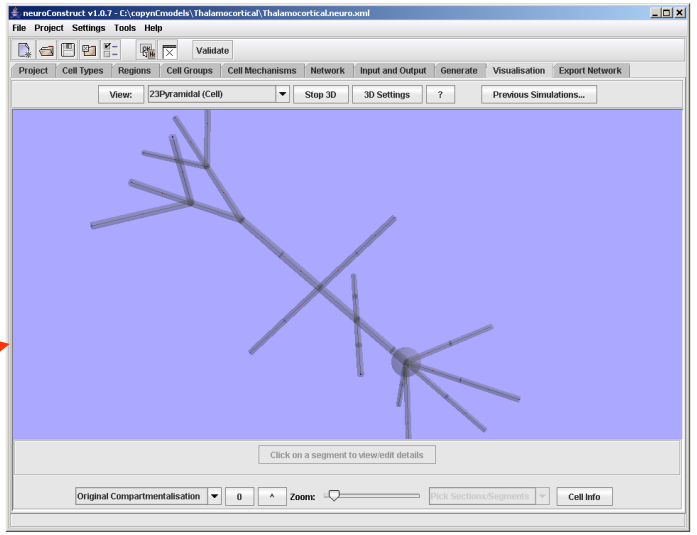
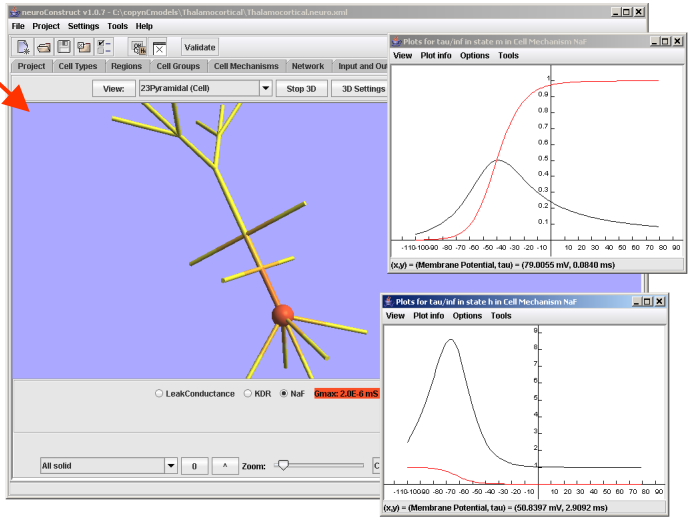
30+ simulators/applications/databases/libraries support NeuroML


Biological scale of information processing in neural system
Levels in NeuroML specifications
Systems level
Local circuits
Neurons
Dendritic subtree
Membrane/synapse
Level 3: NetworkML
Level 1: Metadata & MorphML
Level 2: Biophysics & ChannelML


neuroConstruct v1.0.7 - C:\copyn\models\Thalamocortical\ThalamocorticalNeuro.xml
File Project Settings Tools Help
Validate
Project Cell Types Regions Cell Groups Cell Mechanisms Network Input and Output Generate Visualisation Export Network
View: 23Pyramidal (Cell)
Stop 3D
3D Settings
?
Previous Simulations...
Click on a segment to view/edit details
Original Compartmentalisation
Zoom:
Pick Sections/Segments
Cell Info







$$G_{na}(v,t) = G_{max} * m(v,t)^{3} * h(v,t)$$

$$I_{na}(v,t) = G_{na}(v,t) * (v - E_{na})$$

$$c_1 \leftrightarrow 3c_2 \leftrightarrow c_3 \leftrightarrow c_4$$

o_1 o_2

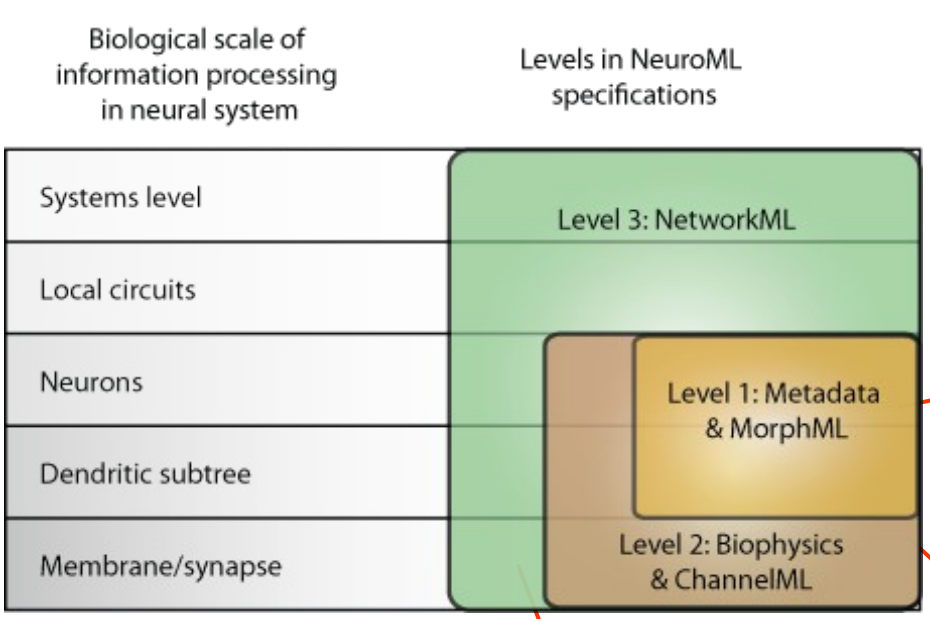
$c_1 \leftrightarrow c_2$ $\alpha = 200\ ms^{-1}\ mM^{-1}$; $\beta = 0.08\ ms^{-1}$

$c_2 \leftrightarrow c_3$ $\alpha = 160\ ms^{-1}\ mM^{-1}$; $\beta = 0.08\ ms^{-1}$

$c_3 \leftrightarrow c_4$ $\alpha = 80\ ms^{-1}\ mM^{-1}$; $\beta = 0.2\ ms^{-1}$

$c_3 \leftrightarrow o1$ $\alpha = 0.16\ ms^{-1}$; $\beta = 1\ ms^{-1}$

$c_4 \leftrightarrow o_2$ $\alpha = 1.2\ ms^{-1}$; $\beta = 0.1\ ms^{-1}$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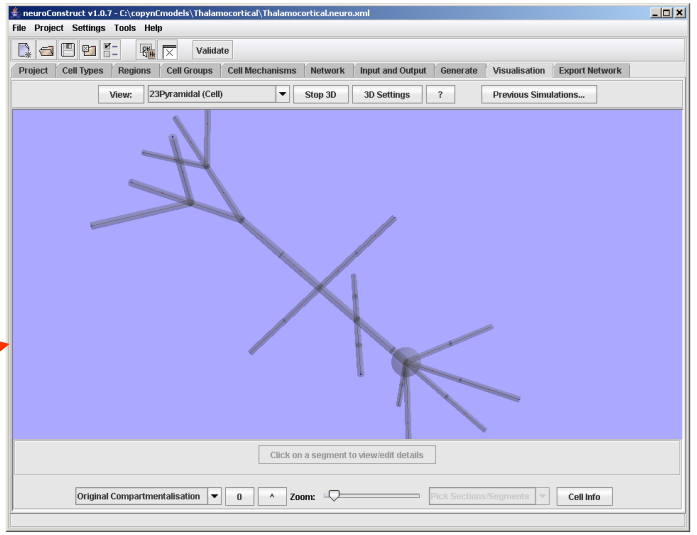
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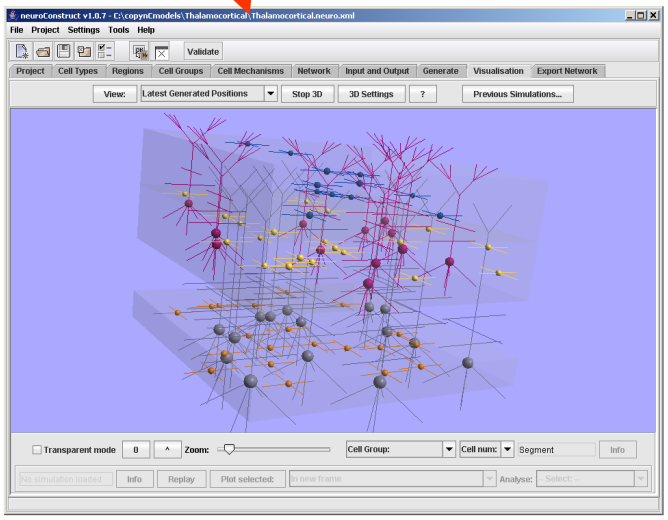
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3D Settings
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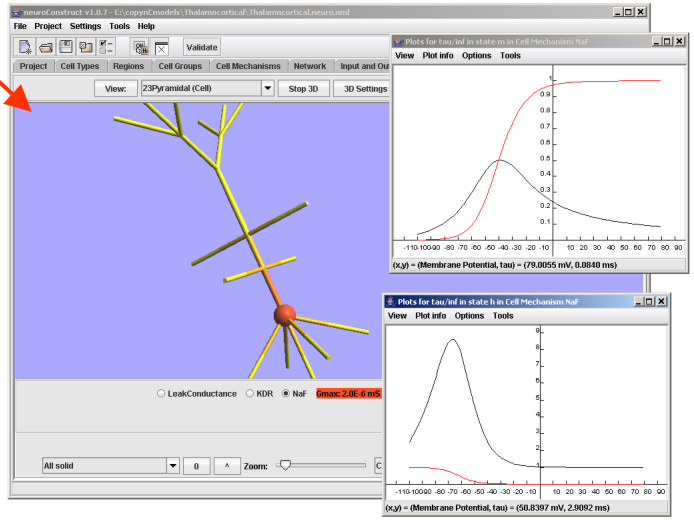
Previous Simulations...
Transparent mode
Zoom:
Cell Group:
Cell num:
Segment
Info
No simulation loaded
Info
Replay
Plot selected:
In new frame
Analyse:
Select...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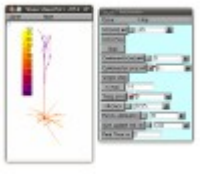
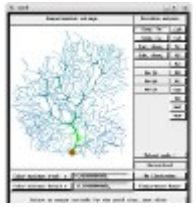
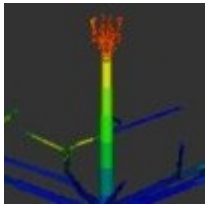
3D Settings
Plots for tau/inf in state m in Cell Mechanism NaF
View Plot info Options Tools
(x,y) = (Membrane Potential, tau) = (79.0055 mV, 0.0840 ms)
Plots for tau/inf in state h in Cell Mechanism NaF
View Plot info Options Tools
(x,y) = (Membrane Potential, tau) = (50.8397 mV, 2.9092 ms)
LeakConductance
KDR
NaF
Gmax:2.0E-6 mS
All solid
Zoom:



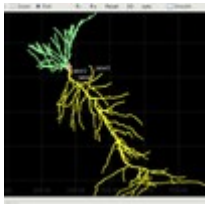
NEURON



GENESIS

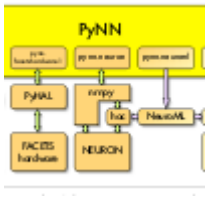


MOOSE



PSICS

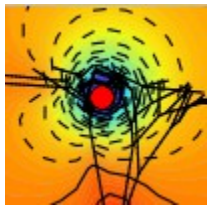
NeuroSpaces



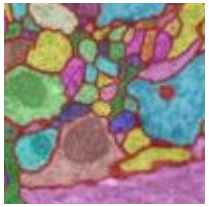
PyNN

neuroConstruct

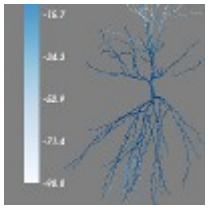
OpenWorm



LFPy

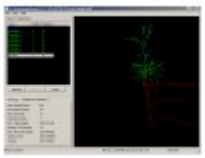


TrakEM

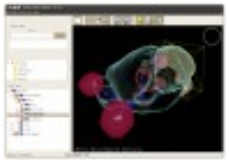


Neuronvisio

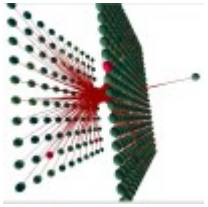
Moogli



NeuronLand

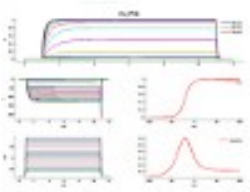


Whole Brain Catalog



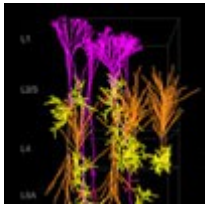
NeurAnim

NeuroMorpho

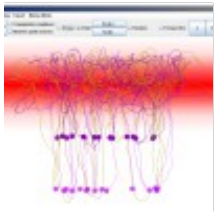


Channelpedia

TREES toolbox

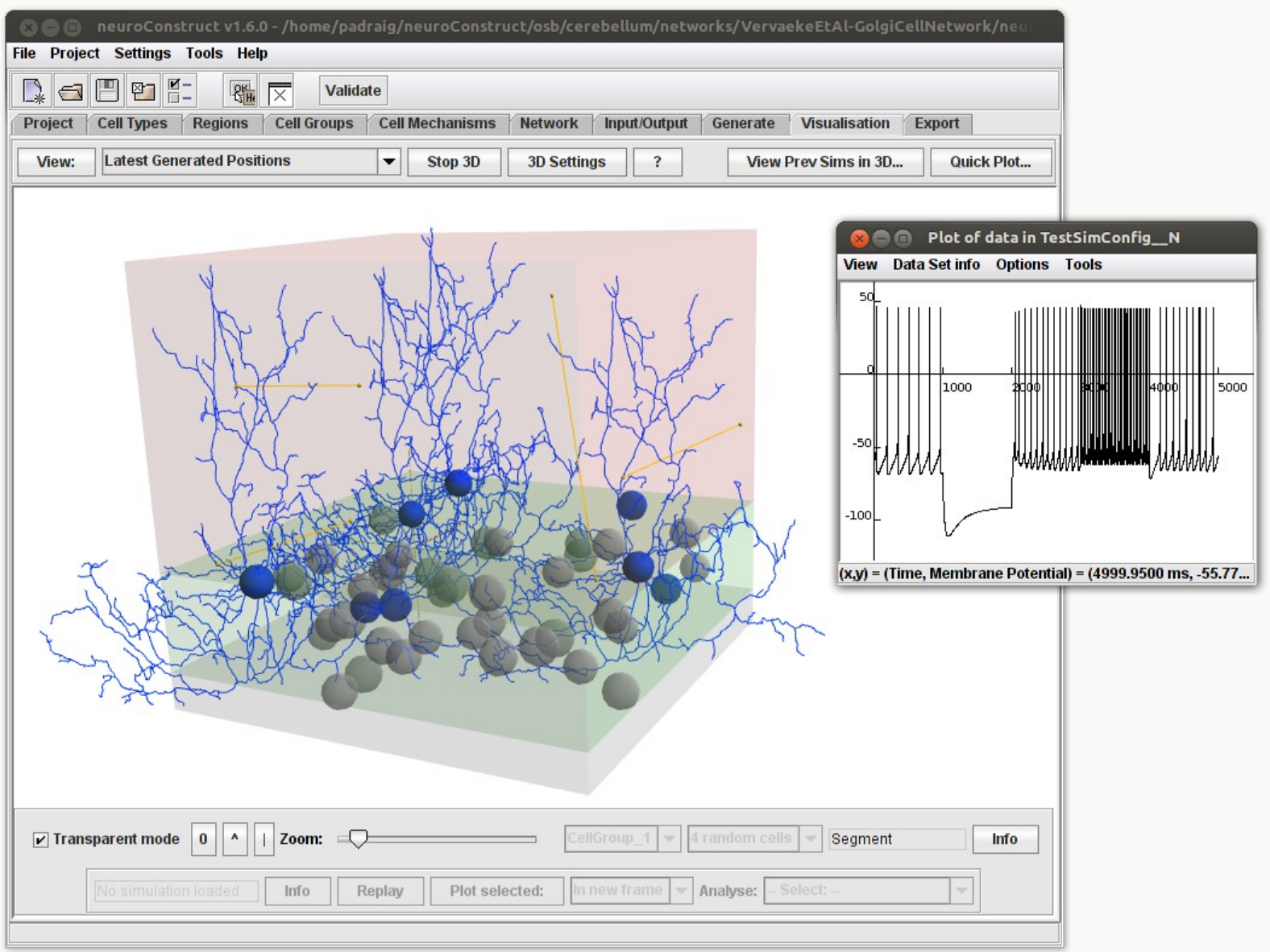


NeuGen

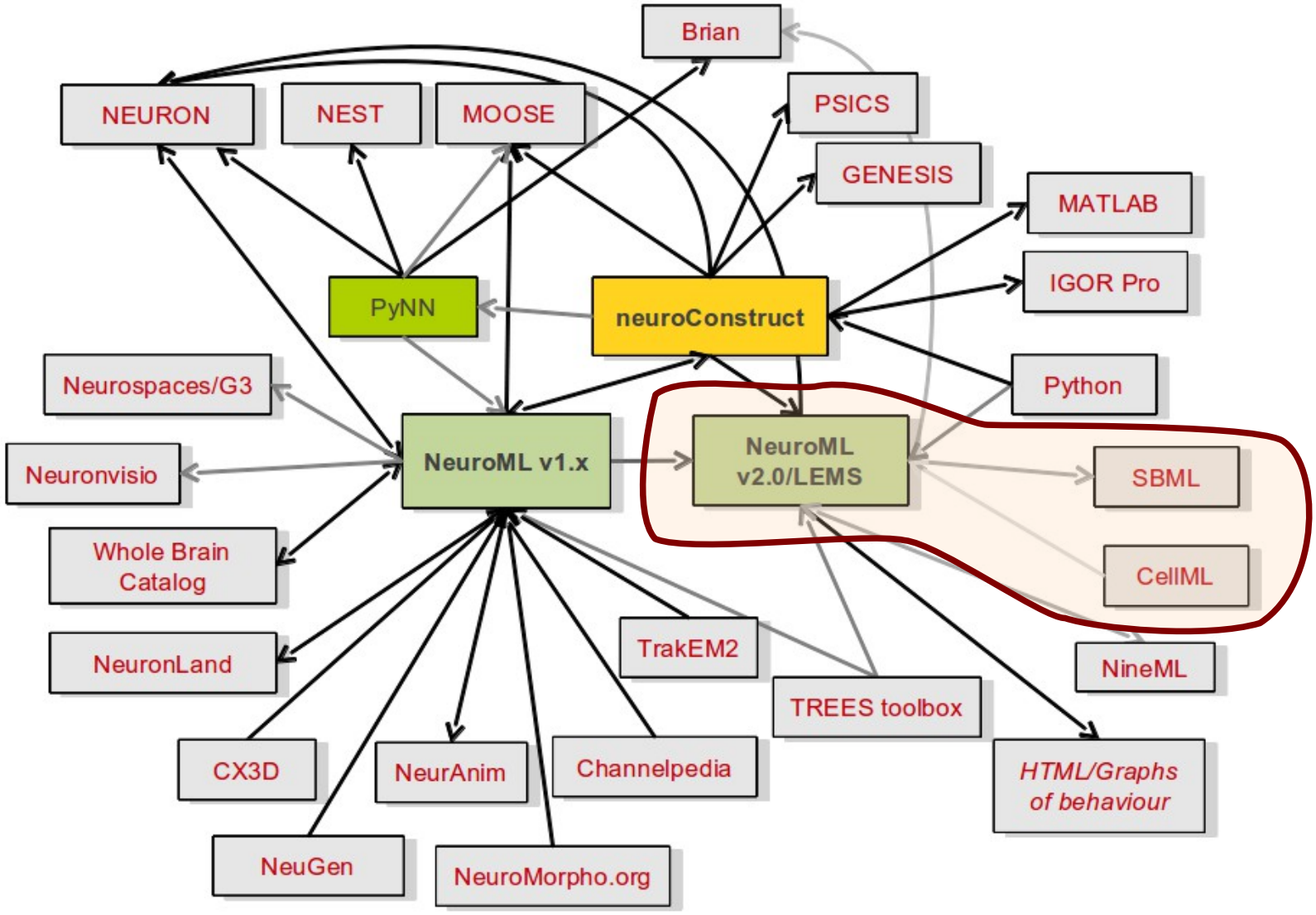


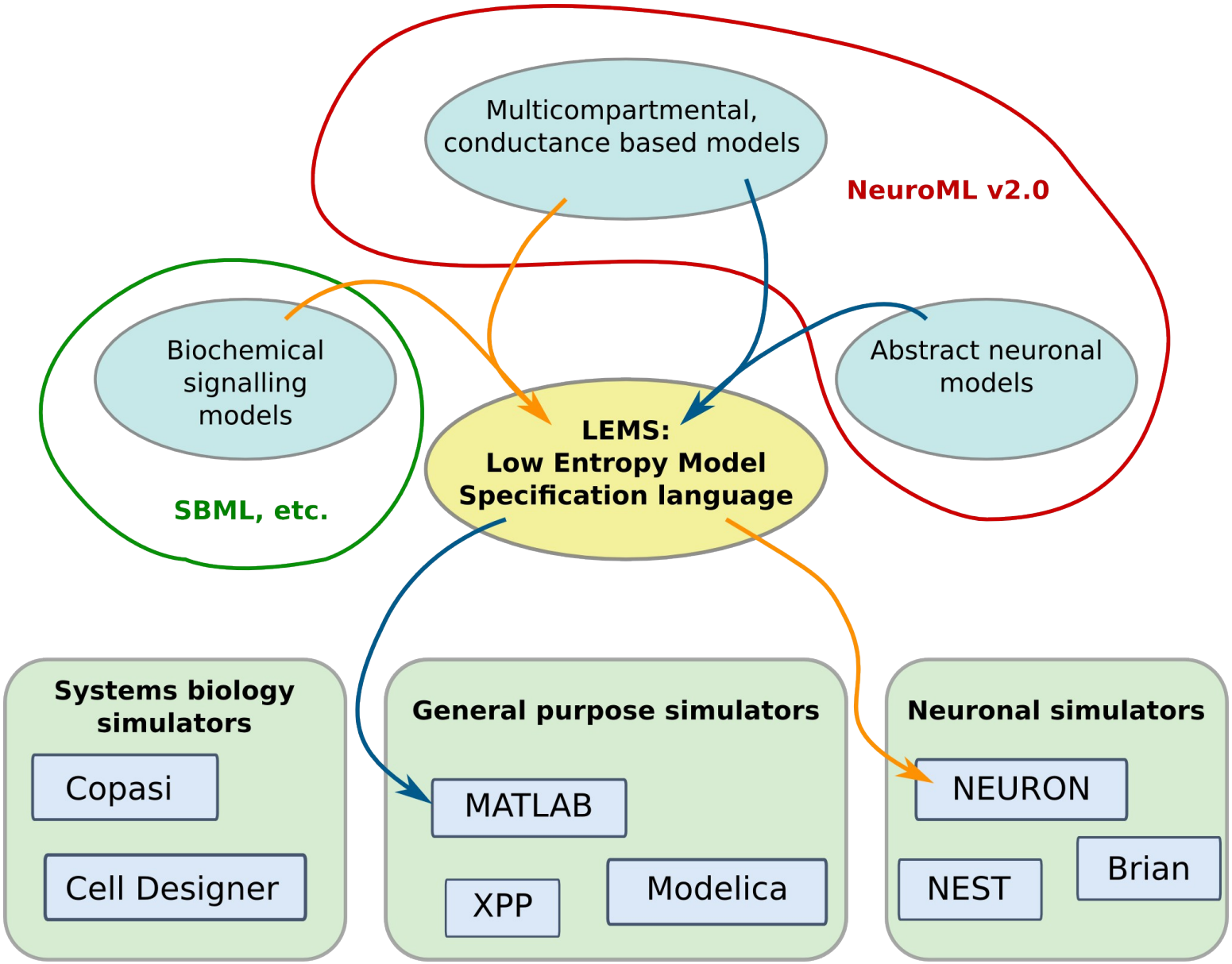
CX3D

neuroConstruct



Wider interoperability framework




Multicompartmental, conductance based models
NeuroML v2.0
Biochemical signalling models
Abstract neuronal models
LEMS: Low Entropy Model Specification language
SBML, etc.
Systems biology simulators
Copasi
Cell Designer
General purpose simulators
MATLAB
XPP
Modelica
Neuronal simulators
NEURON
NEST
Brian

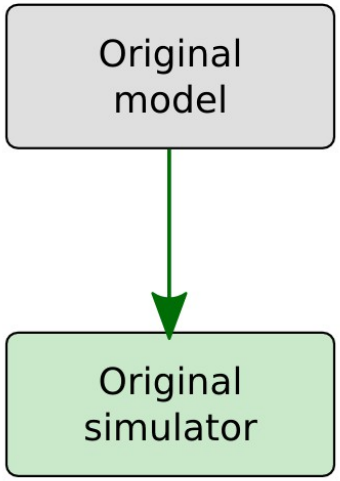
(Distributed) Version Control

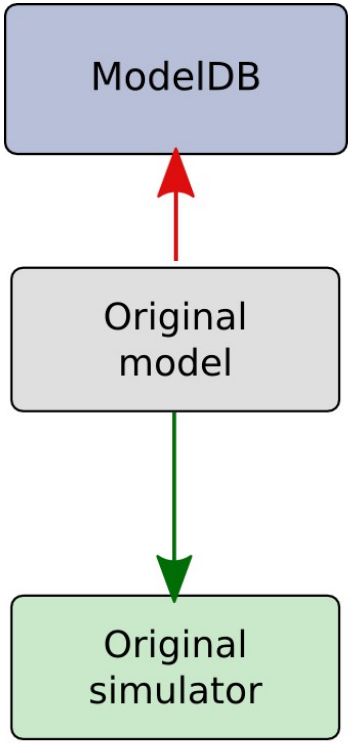
Progress through the ages:

- **CVS**: allowed small groups to collaborate on software development
- **Subversion:** atomic commits; widely used by SourceForge & Google Code
- **Git, Mercurial, Bazaar:** distributed version control system; enable feature rich sites like GitHub

Workflow

How does a model develop on OSB?


Original
model
Original
simulator


ModelDB
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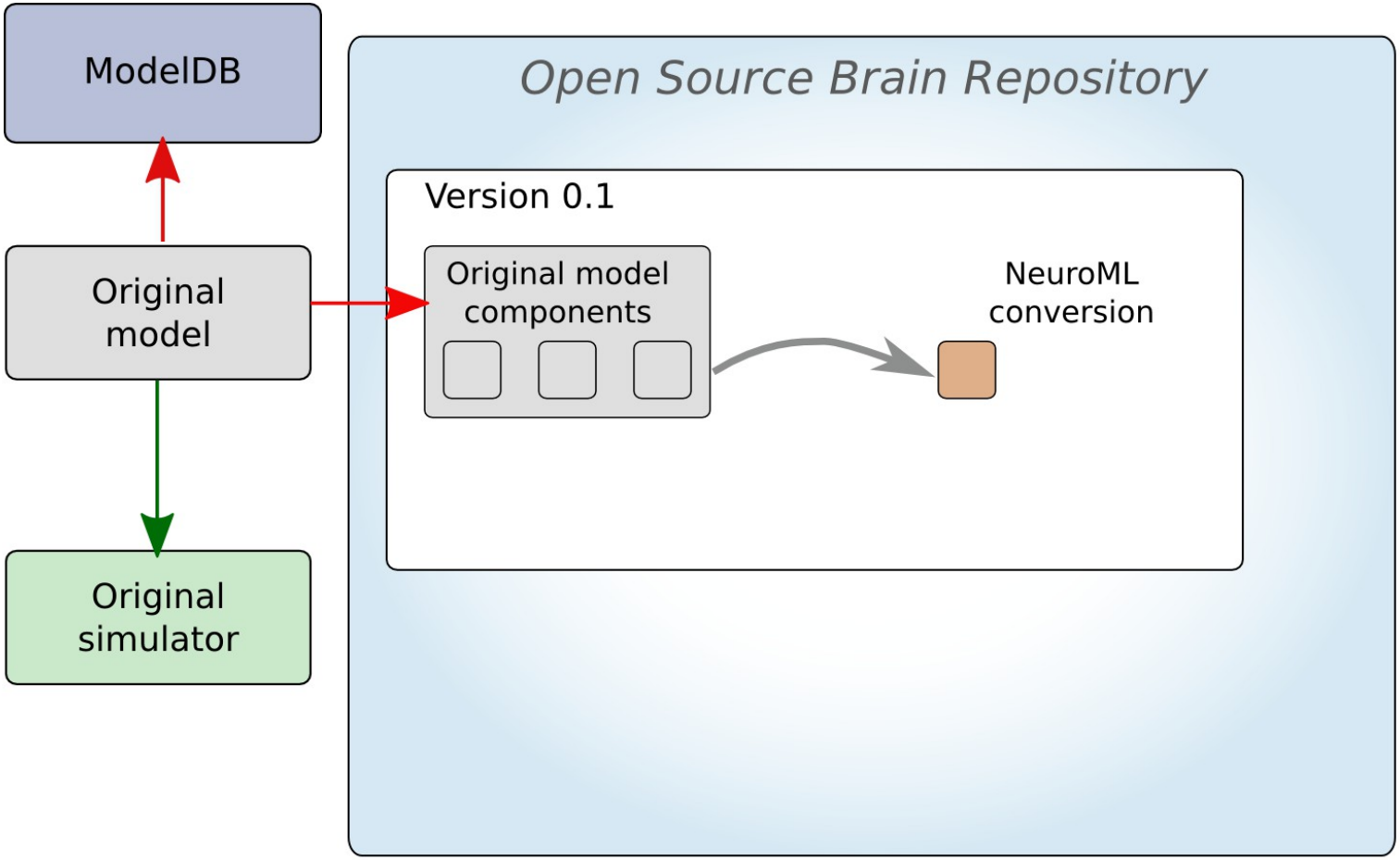
ModelDB
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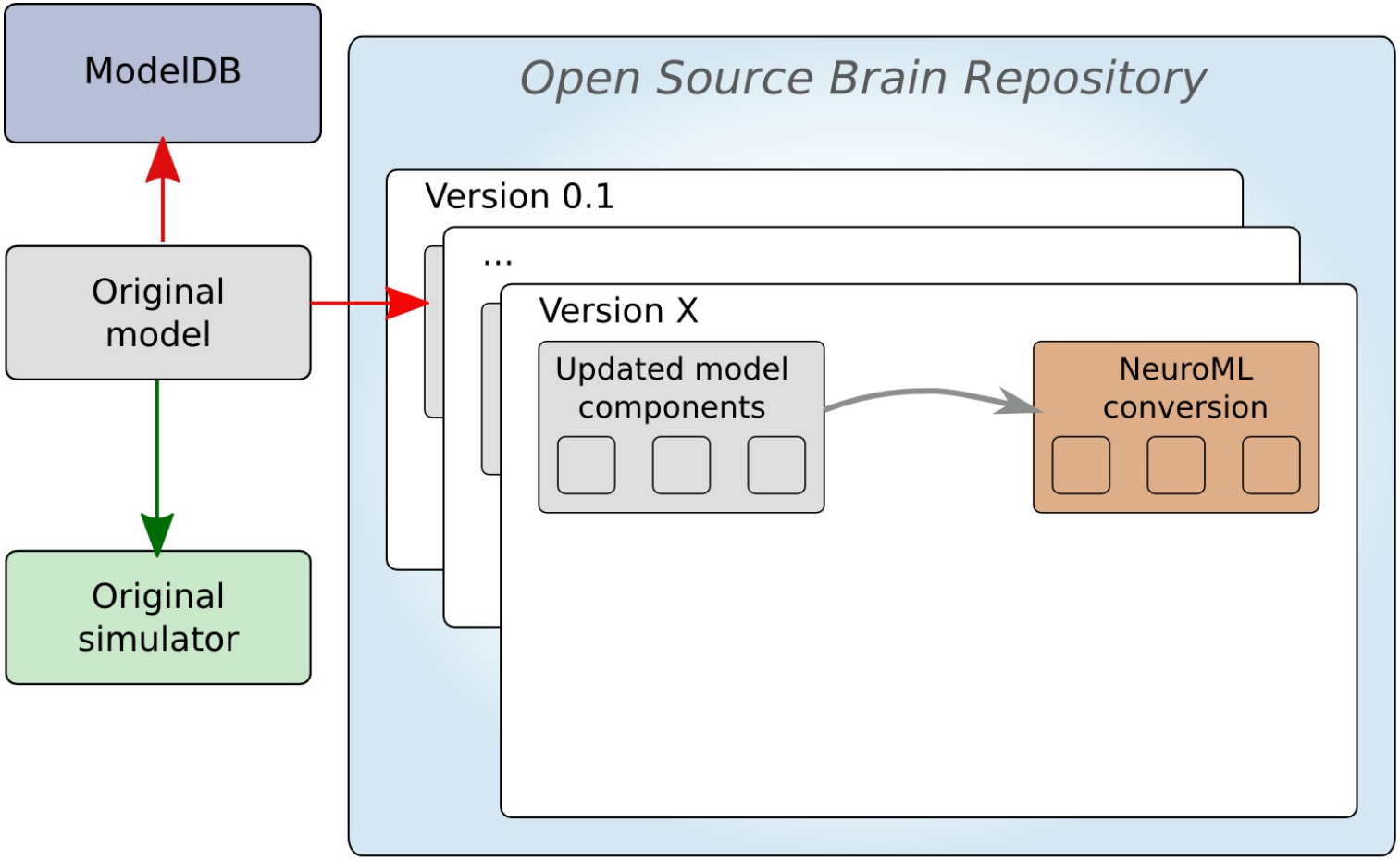
Open Source Brain Repository
Version 0.1
Original model components
NeuroML conversion


ModelDB
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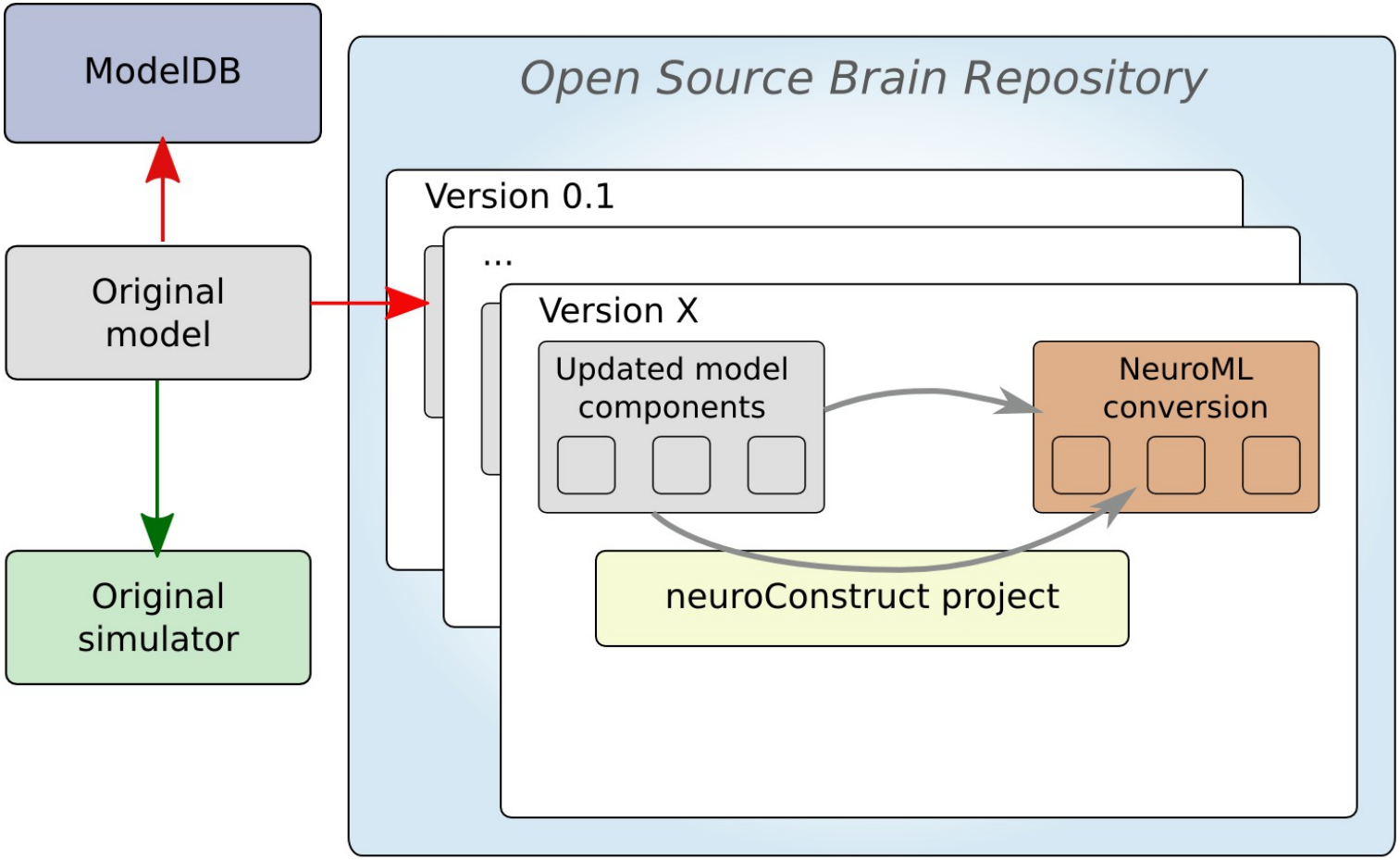
...
Version X
Updated model components
NeuroML conversion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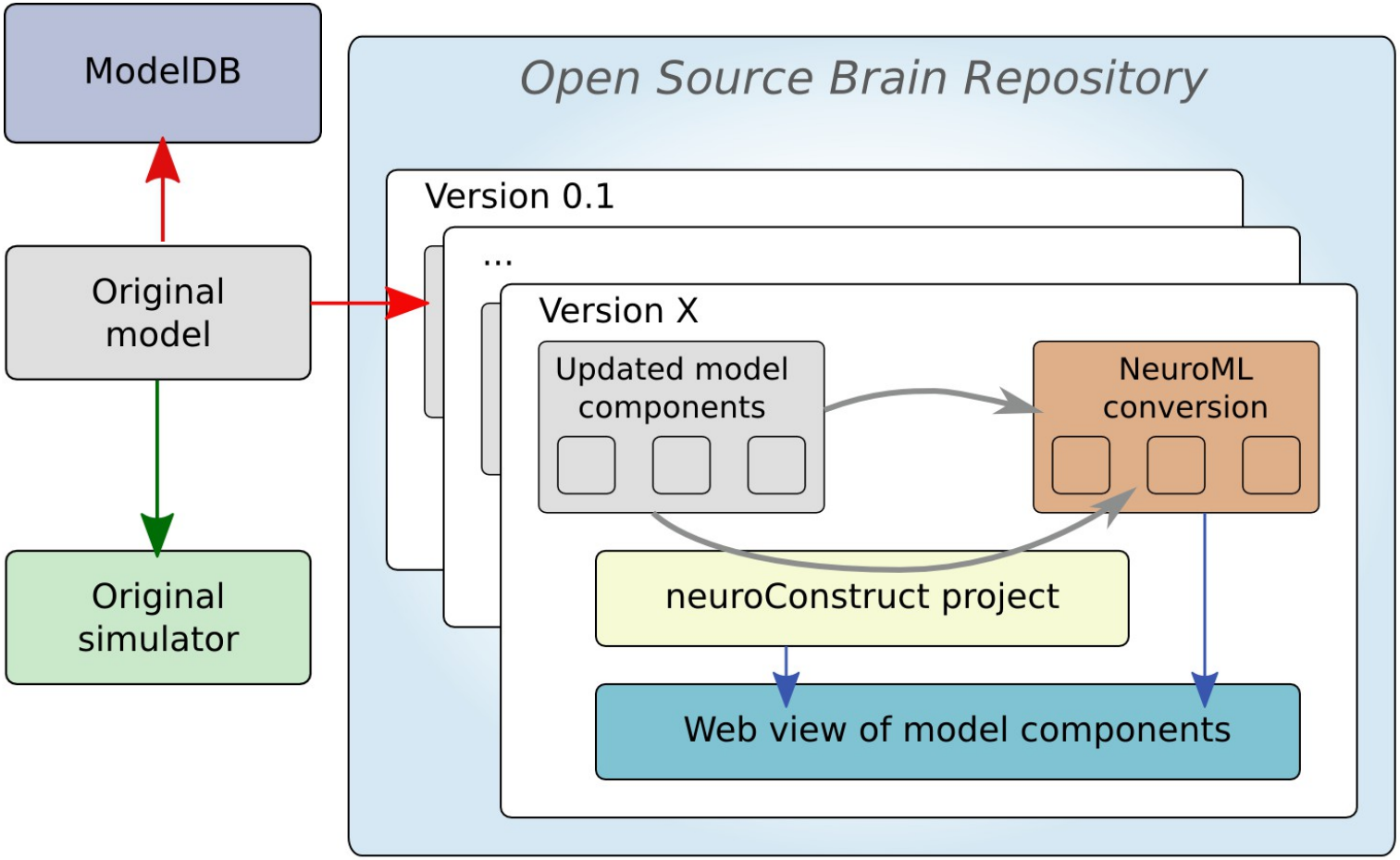
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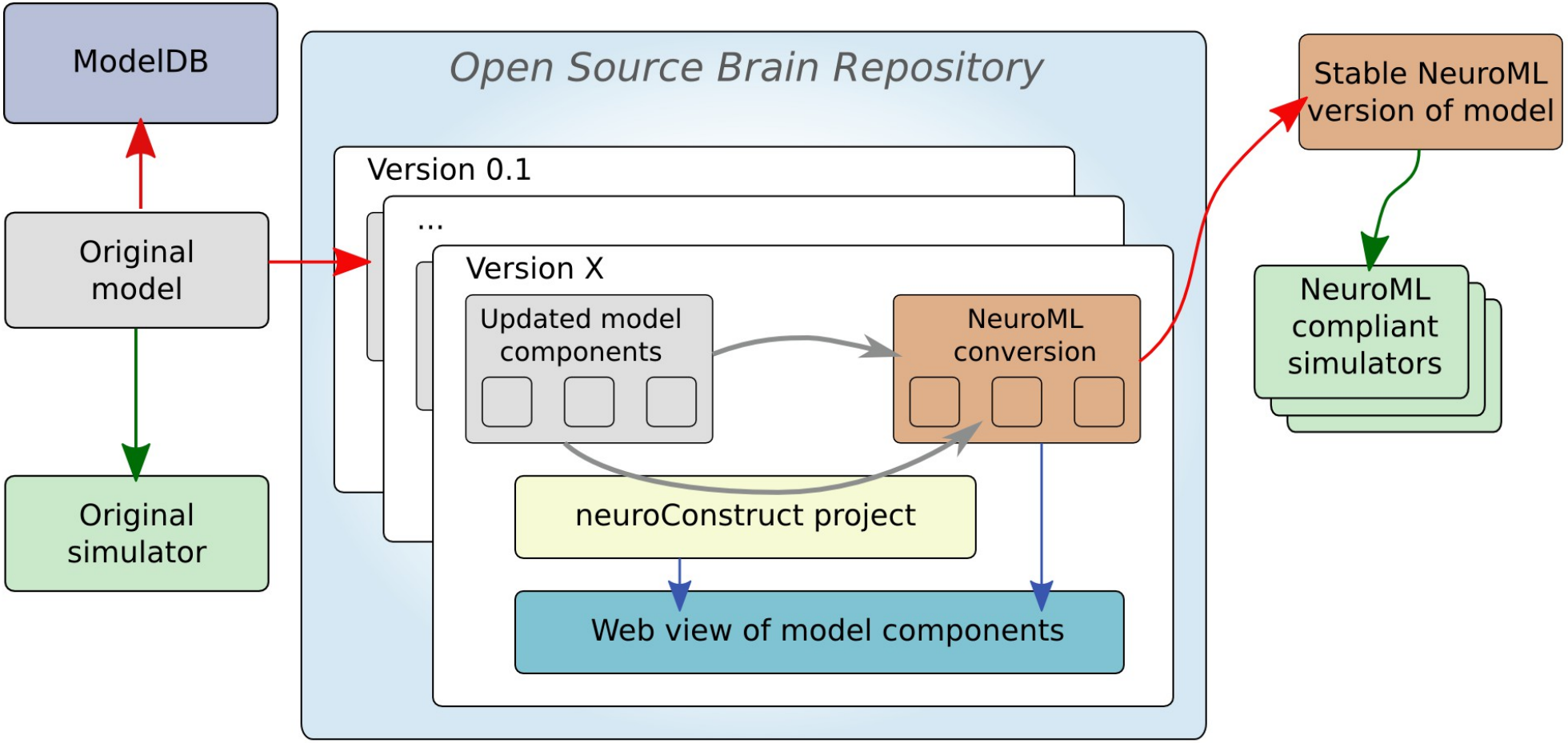
Web view of model components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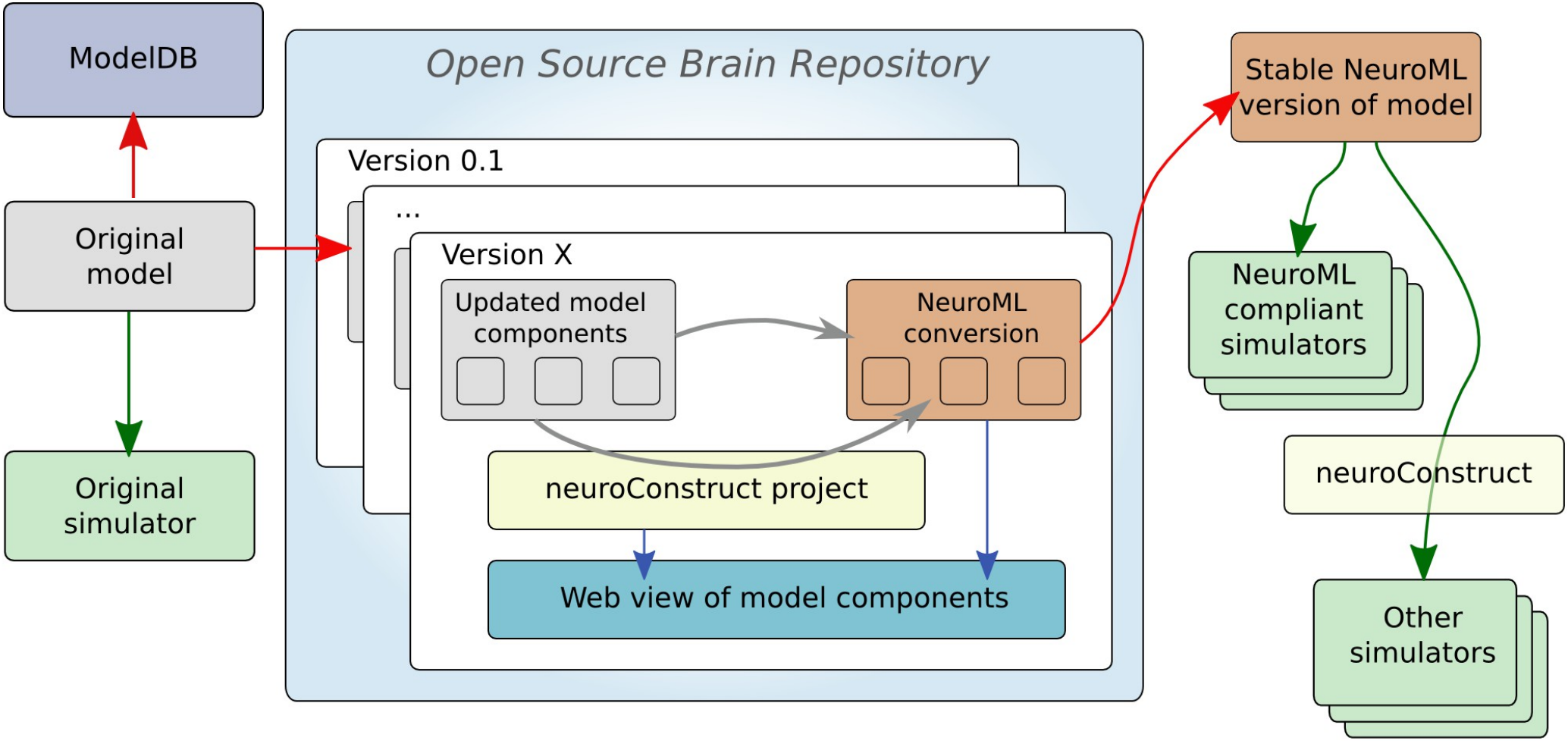
Stable NeuroML version of model
NeuroML compliant simulators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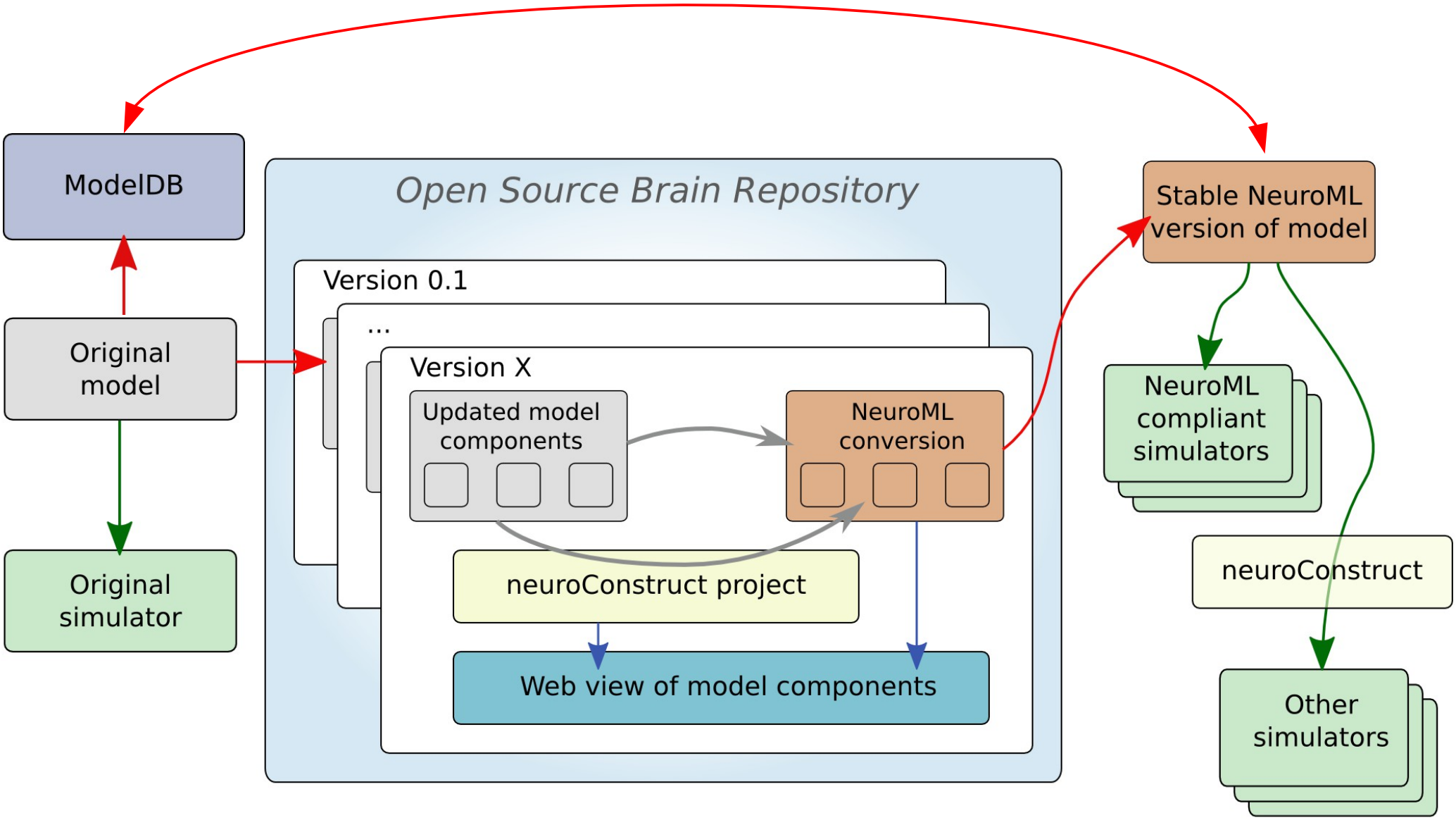
Other simulators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Existing models in OSB

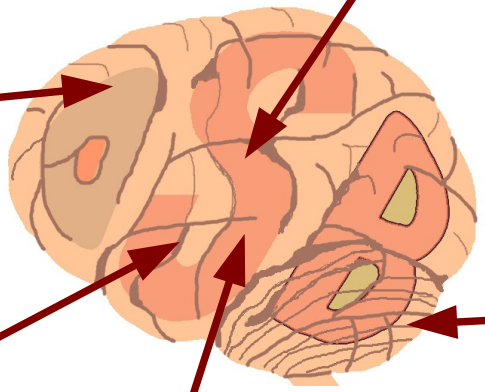
Conversions of models from ModelDB

Neocortex

Mainen et al. (1995)
L5 Pyramidal cell
Rothman et al. (2010)
L5 Pyramidal cell
Traub et al. (2005)
L2/3 Pyr (FRB/RS), L4SS, L5 Pyr (IB/RS), L6 Pyr, Deep & superficial basket, axo-axonic & LTS interneurons, Cortical column network model

Basal Ganglia

Blackwell et al (in press)
Medium Spiny Neuron



Cerebellum

Maex and Schutter (1998)
Granule cell layer
Steuber and Saviane, based on Berends et al. (2005)
Granule cell
Vervaeke et al. (2010)
Golgi cell network
Solinas et al. (2007a,b)
Granule cell, Golgi cell
De Schutter and Bower (1994)
Purkinje cell
Steuber et al. (2011)
Cerebellar nucleus neuron

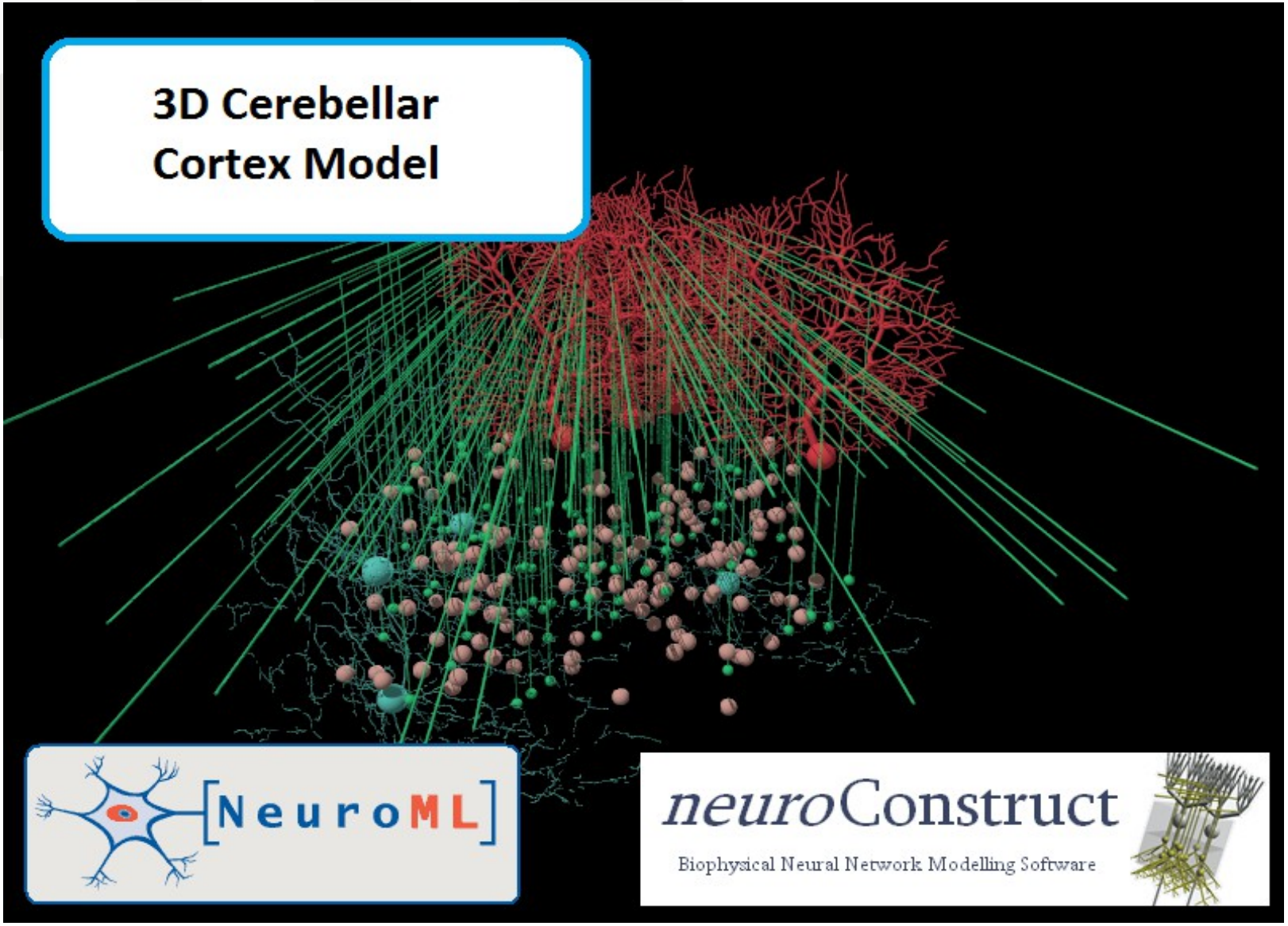
Hippocampus

Migliore et al. (2005)
CA1 Pyramidal cell

Thalamus

Traub et al. (2005)
Thalamocortical relay cell, Nucleus reticularis thalami cell

Examples


3D Cerebellar
Cortex Model
[NeuroML]
neuroConstruct
Biophysical Neural Network Modelling Software

Collaborative modelling

What features enable this?

Example of conversion process

Cerebellar granule cell model from:

Solinas S., Nieus T, D'Angelo E. (2010) **A Realistic Large-Scale Model of the Cerebellum Granular Layer Predicts Circuit Spatio-Temporal Filtering Properties.** Front Cell Neurosci. 2010;4:12.

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Originally developed in NEURON

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Originally developed in NEURON

neuroConstruct project facilitated conversion to NeuroML

Overview - GranCellSolina

www.opensourcebrain.org/projects/grancellsolinasetal10

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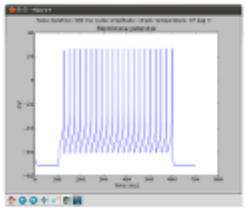
undergoing maintenence & major restructuring prior to launch at CNS 2012...-->

Overview



Initial version of Granule cell from: Solinas S., Nieus T, d'Angelo E. (2010) A Realistic Large-Scale Model of the Cerebellum Granular Layer Predicts Circuit Spatio-Temporal Filtering Properties. Front Cell Neurosci. 2010;4:12.

For more information, see the Wiki

Members

Developer: Eugenio Piasini, Padraig Gleeson, Sergio Solinas
Scientific Coordinator: Sergio Solinas

Latest news

Automated test on spike times & saving morphs as NeuroML
Added by Padraig Gleeson about 1 month ago

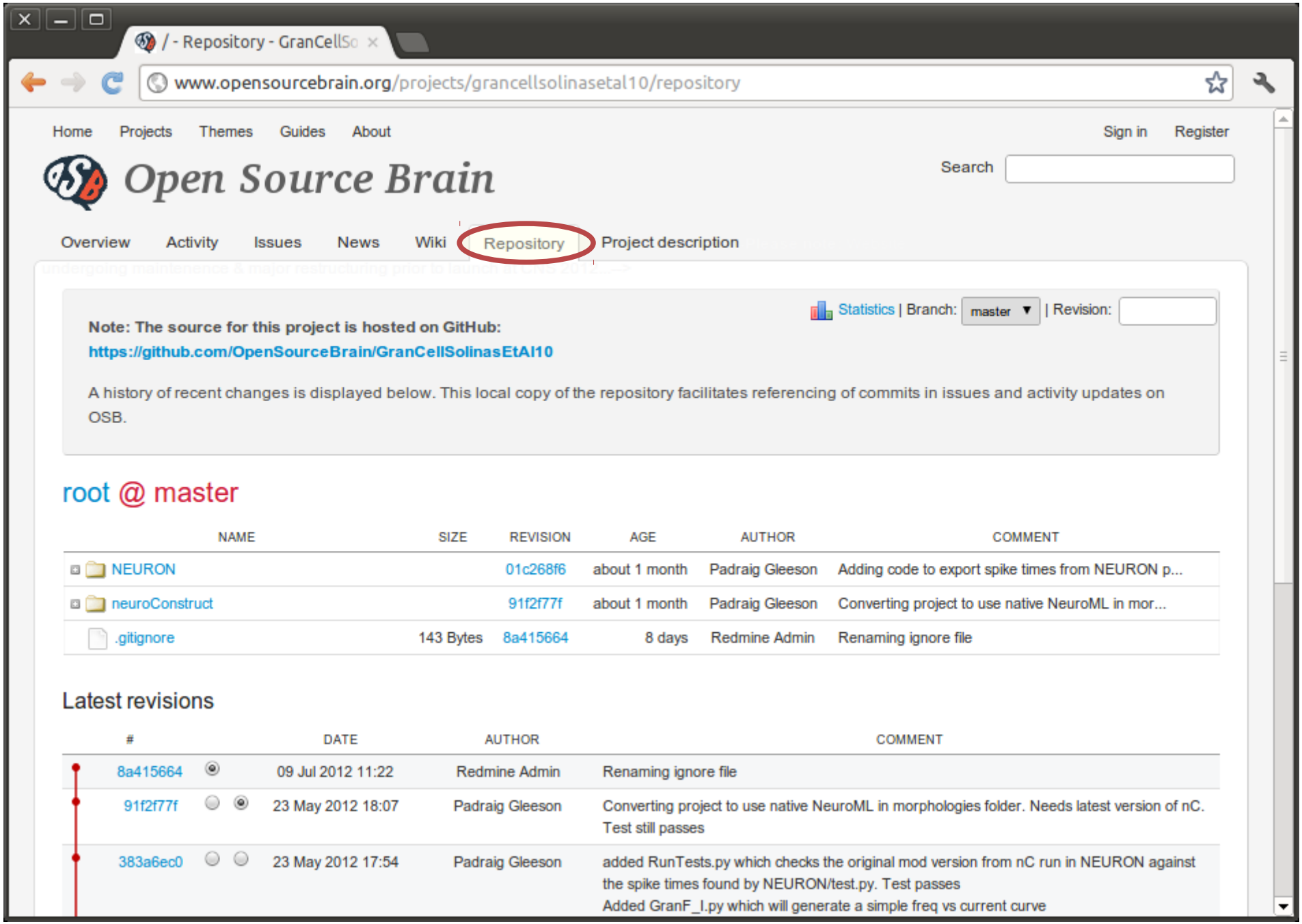
View all news

NeuroML compatibility

The minimum version of NeuroML for this model is: **v1.x**

GitHub repository

The source for this project is hosted on GitHub:
https://github.com/OpenSourceBrain/GranCellSolinasEtAl10


/ - Repository - GranCellSo
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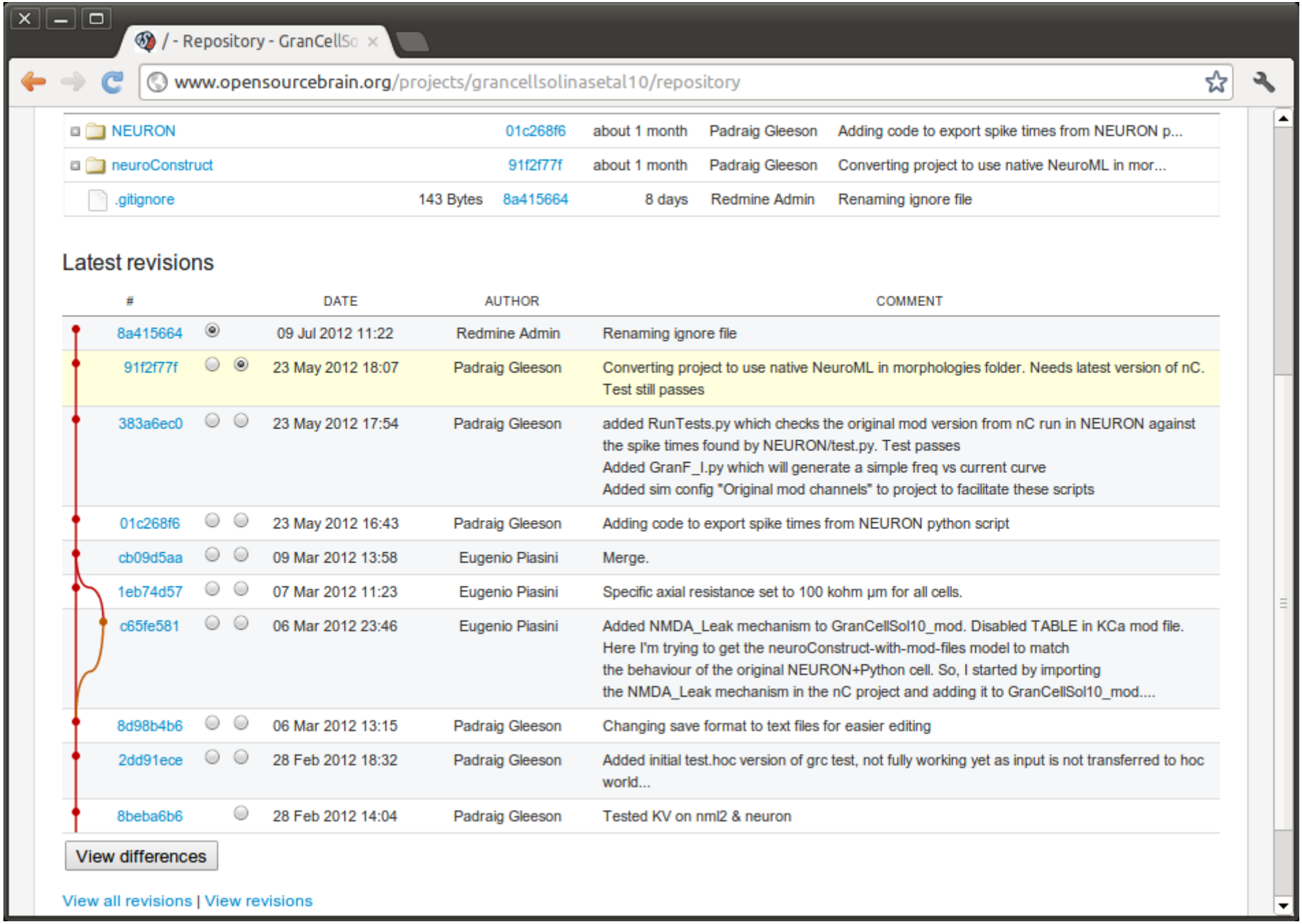
Statistics | Branch: master | Revision:
Note: The source for this project is hosted on GitHub:
https://github.com/OpenSourceBrain/GranCellSolinasEtAl10
A history of recent changes is displayed below. This local copy of the repository facilitates referencing of commits in issues and activity updates on OSB.
root @ master
NAME SIZE REVISION AGE AUTHOR COMMENT
NEURON 01c268f6 about 1 month Padraig Gleeson Adding code to export spike times from NEURON p...
neuroConstruct 91f2f77f about 1 month Padraig Gleeson Converting project to use native NeuroML in mor...
.gitignore 143 Bytes 8a415664 8 days Redmine Admin Renaming ignore file
Latest revisions
DATE AUTHOR COMMENT
8a415664 09 Jul 2012 11:22 Redmine Admin Renaming ignore file
91f2f77f 23 May 2012 18:07 Padraig Gleeson Converting project to use native NeuroML in morphologies folder. Needs latest version of nC. Test still passes
383a6ec0 23 May 2012 17:54 Padraig Gleeson added RunTests.py which checks the original mod version from nC run in NEURON against the spike times found by NEURON/test.py. Test passes
Added GranF_I.py which will generate a simple freq vs current curve


/ - Repository - GranCellSo
www.opensourcebrain.org/projects/grancellsolinasetal10/repository
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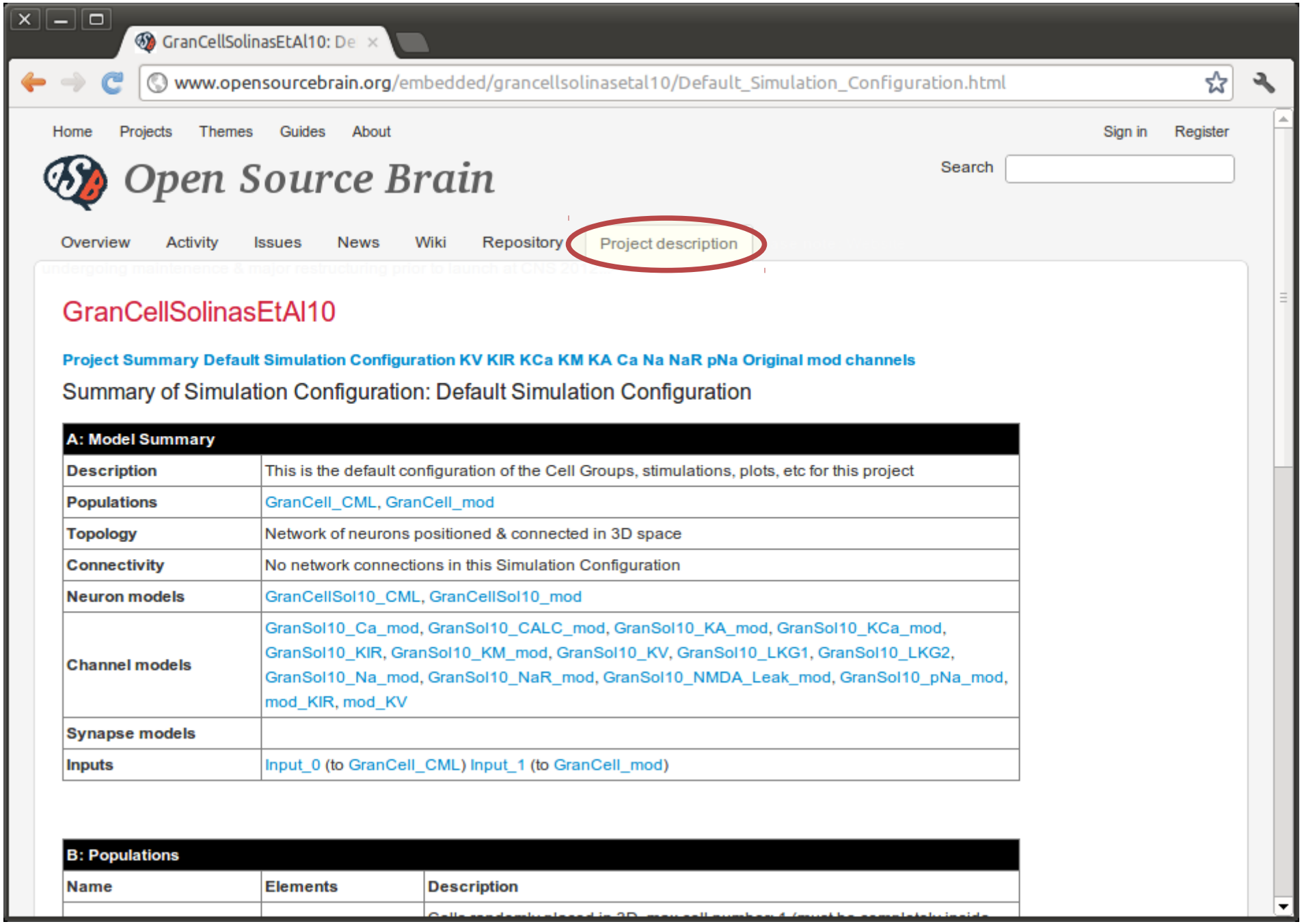
Added GranF_I.py which will generate a simple freq vs current curve
Added sim config "Original mod channels" to project to facilitate these scripts
01c268f6 23 May 2012 16:43 Padraig Gleeson Adding code to export spike times from NEURON python script
cb09d5aa 09 Mar 2012 13:58 Eugenio Piasini Merge.
1eb74d57 07 Mar 2012 11:23 Eugenio Piasini Specific axial resistance set to 100 kohm µm for all cells.
c65fe581 06 Mar 2012 23:46 Eugenio Piasini Added NMDA_Leak mechanism to GranCellSol10_mod. Disabled TABLE in KCa mod file.
Here I'm trying to get the neuroConstruct-with-mod-files model to match
the behaviour of the original NEURON+Python cell. So, I started by importing
the NMDA_Leak mechanism in the nC project and adding it to GranCellSol10_mod....
8d98b4b6 06 Mar 2012 13:15 Padraig Gleeson Changing save format to text files for easier editing
2dd91ece 28 Feb 2012 18:32 Padraig Gleeson Added initial test.hoc version of grc test, not fully working yet as input is not transferred to hoc world...
8beba6b6 28 Feb 2012 14:04 Padraig Gleeson Tested KV on nml2 & neuron
View differences
View all revisions | View revisions


GranCellSolinasEtAl10: De
www.opensourcebrain.org/embedded/grancellsolinasetal10/Default_Simulation_Configuration.html
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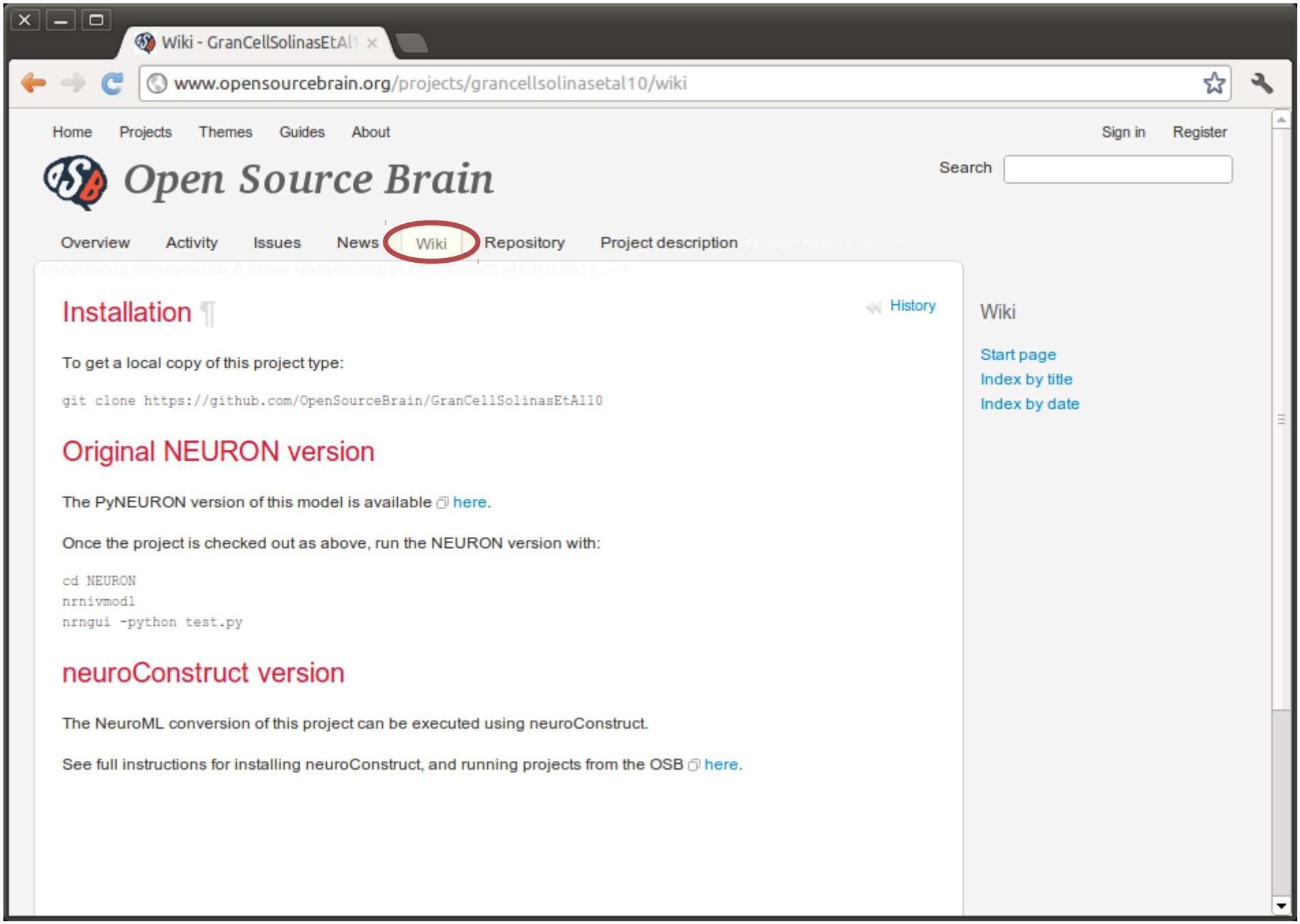
Project description
GranCellSolinasEtAl10
Project Summary Default Simulation Configuration KV KIR KCa KM KA Ca Na NaR pNa Original mod channels
Summary of Simulation Configuration: Default Simulation Configuration
A: Model Summary
Description
This is the default configuration of the Cell Groups, stimulations, plots, etc for this project
Populations
GranCell_CML, GranCell_mod
Topology
Network of neurons positioned & connected in 3D space
Connectivity
No network connections in this Simulation Configuration
Neuron models
GranCellSol10_CML, GranCellSol10_mod
Channel models
GranSol10_Ca_mod, GranSol10_CALC_mod, GranSol10_KA_mod, GranSol10_KCa_mod, GranSol10_KIR, GranSol10_KM_mod, GranSol10_KV, GranSol10_LKG1, GranSol10_LKG2, GranSol10_Na_mod, GranSol10_NaR_mod, GranSol10_NMDA_Leak_mod, GranSol10_pNa_mod, mod_KIR, mod_KV
Synapse models
Inputs
Input_0 (to GranCell_CML) Input_1 (to GranCell_mod)
B: Populations
Name
Elements
Description


Wiki - GranCellSolinasEtAl
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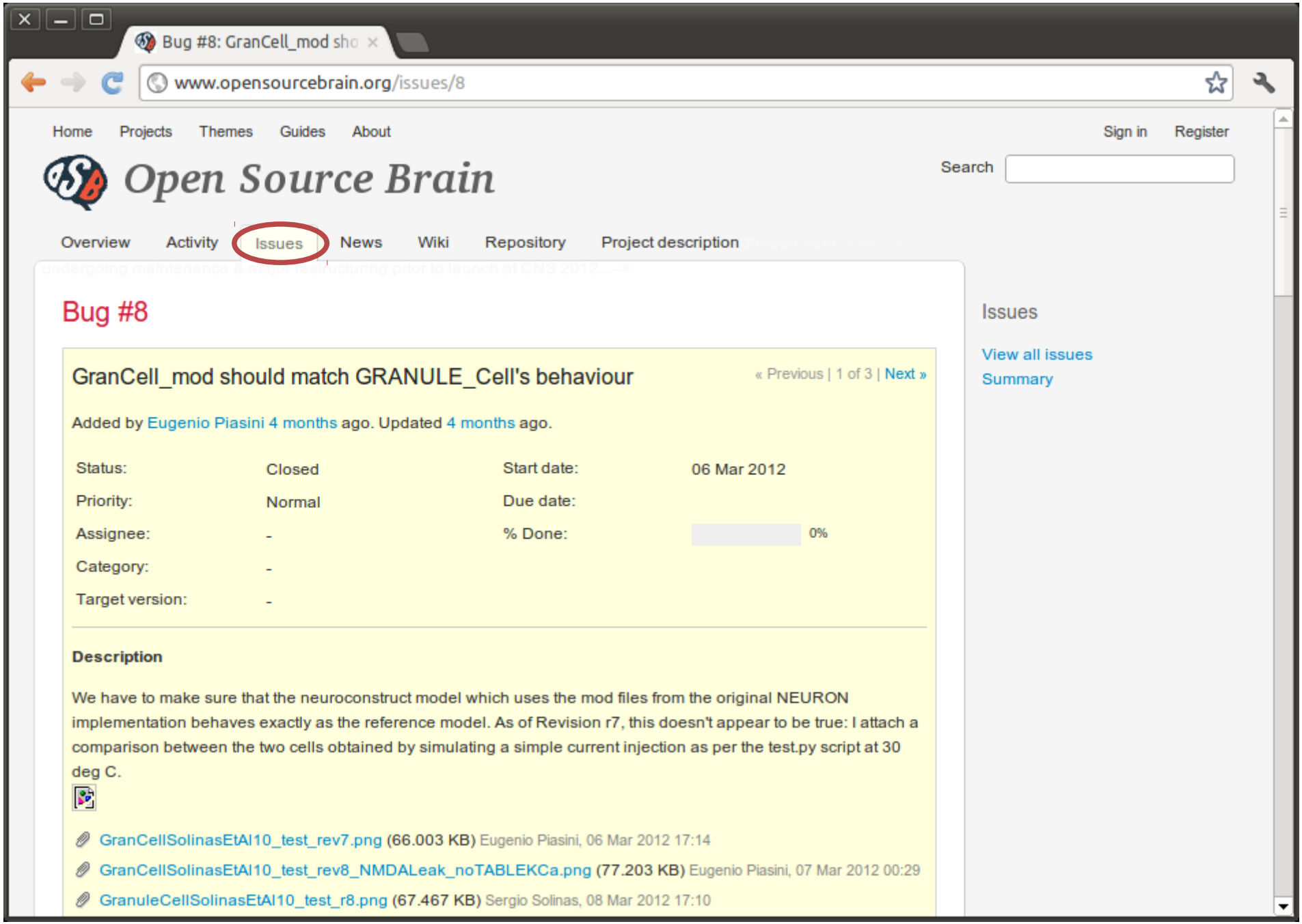
Repository
Project description
Installation ¶
History
To get a local copy of this project type:
git clone https://github.com/OpenSourceBrain/GranCellSolinasEtAl10
Original NEURON version
The PyNEURON version of this model is available here.
Once the project is checked out as above, run the NEURON version with:
cd NEURON
nrnivmodl
nrngui -python test.py
neuroConstruct version
The NeuroML conversion of this project can be executed using neuroConstruct.
See full instructions for installing neuroConstruct, and running projects from the OSB here.
Wiki
Start page
Index by title
Index by date


Bug #8: GranCell_mod sho
www.opensourcebrain.org/issues/8
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Project description
Bug #8
GranCell_mod should match GRANULE_Cell's behaviour
« Previous | 1 of 3 | Next »
Added by Eugenio Piasini 4 months ago. Updated 4 months ago.
Status: Closed
Start date: 06 Mar 2012
Priority: Normal
Due date:
Assignee: -
% Done: 0%
Category: -
Target version: -
Description
We have to make sure that the neuroconstruct model which uses the mod files from the original NEURON implementation behaves exactly as the reference model. As of Revision r7, this doesn't appear to be true: I attach a comparison between the two cells obtained by simulating a simple current injection as per the test.py script at 30 deg C.
GranCellSolinasEtAl10_test_rev7.png (66.003 KB) Eugenio Piasini, 06 Mar 2012 17:14
GranCellSolinasEtAl10_test_rev8_NMDALeak_noTABLEKCa.png (77.203 KB) Eugenio Piasini, 07 Mar 2012 00:29
GranuleCellSolinasEtAl10_test_r8.png (67.467 KB) Sergio Solinas, 08 Mar 2012 17:10
Issues
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Summary

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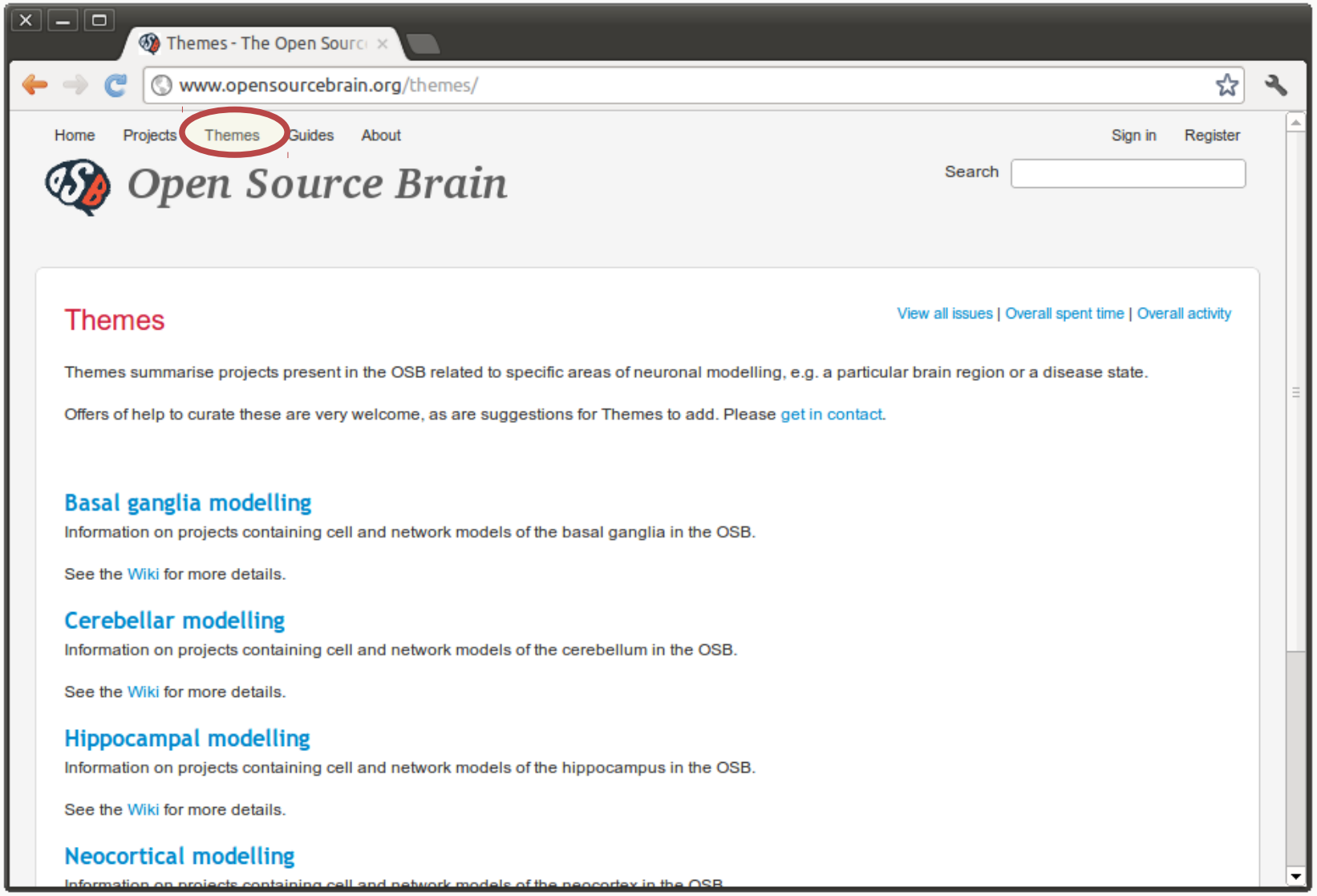
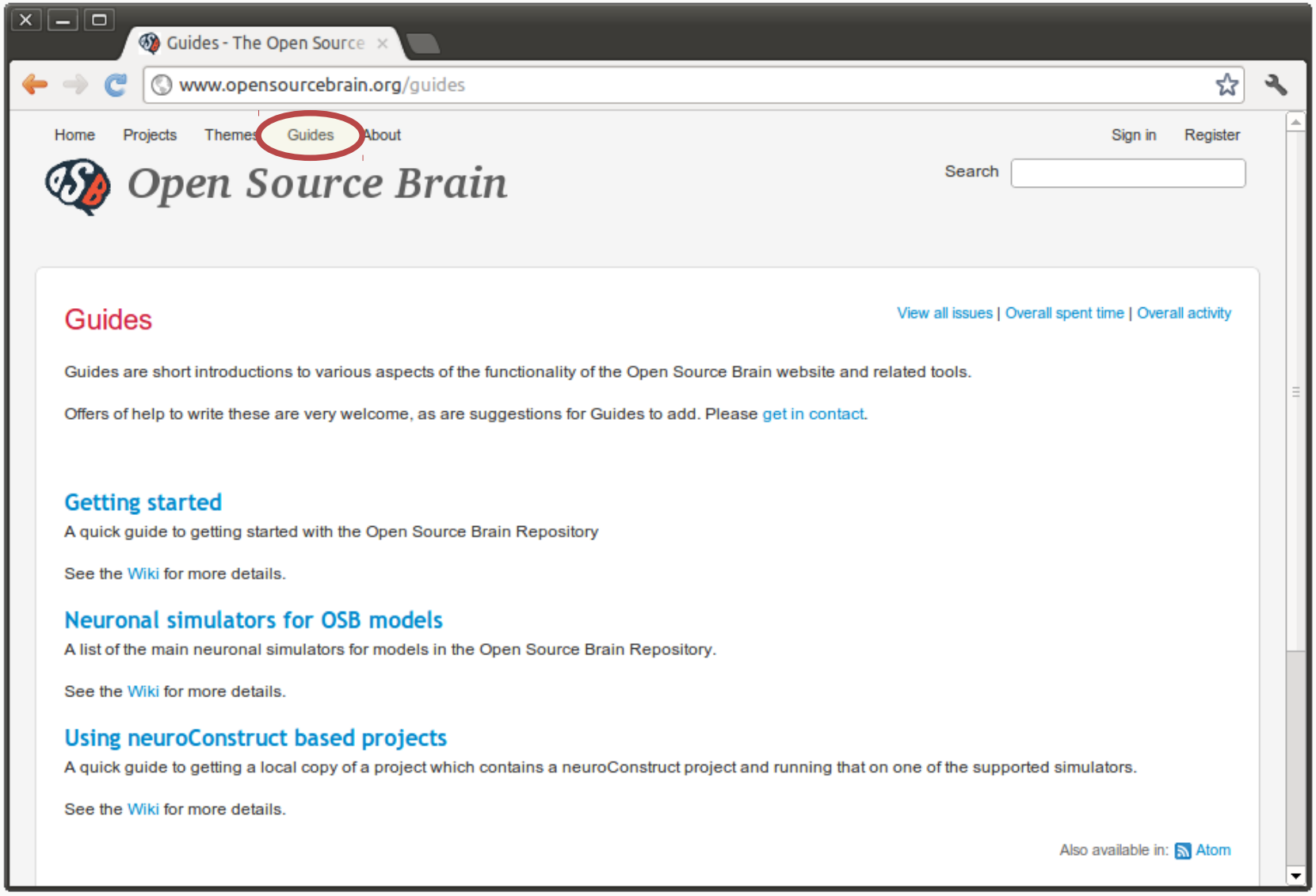


Themes & Guides



Is this realistic?

Will researchers actually collaborate openly & share their models?

Caenorhabditis elegans

Well studied model organism (roundworm)

Complete gene sequence, transparent, 959 cells, complete cell lineage known…

302 neurons in adult hermaphrodite nervous system

Cells named & connectivity known

The OpenWorm Project

Distributed group of computational neuroscientists, physicists, software developers with common goal:

Try to build an open source, biophysically realistic model of C. elegans *in silico*

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> **Try to build an open source, biophysically realistic model of C. elegans *in silico***

Active for ~18 months

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Distributed group of computational neuroscientists, physicists, software developers with common goal:

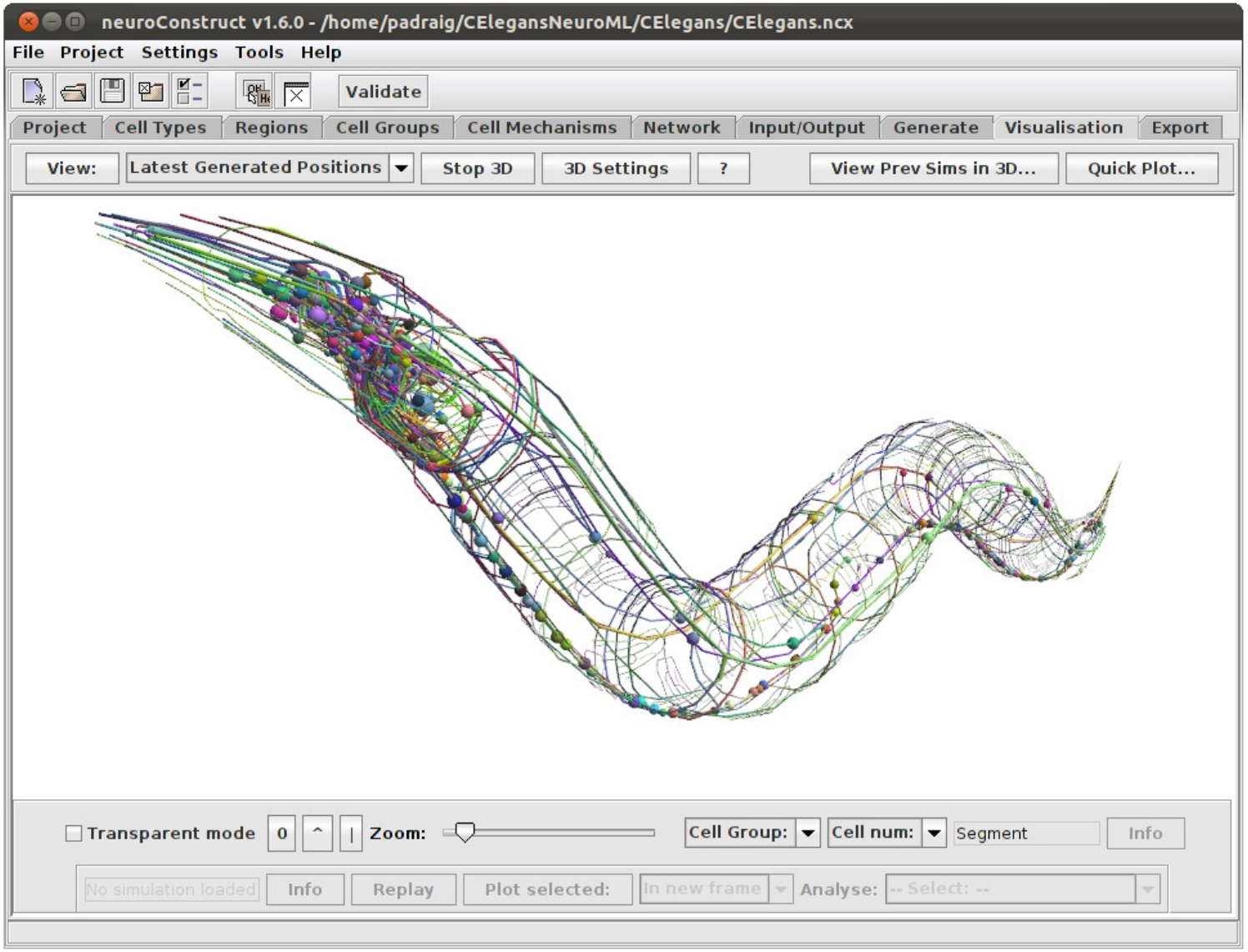
> **Try to build an open source, biophysically realistic model of C. elegans *in silico***

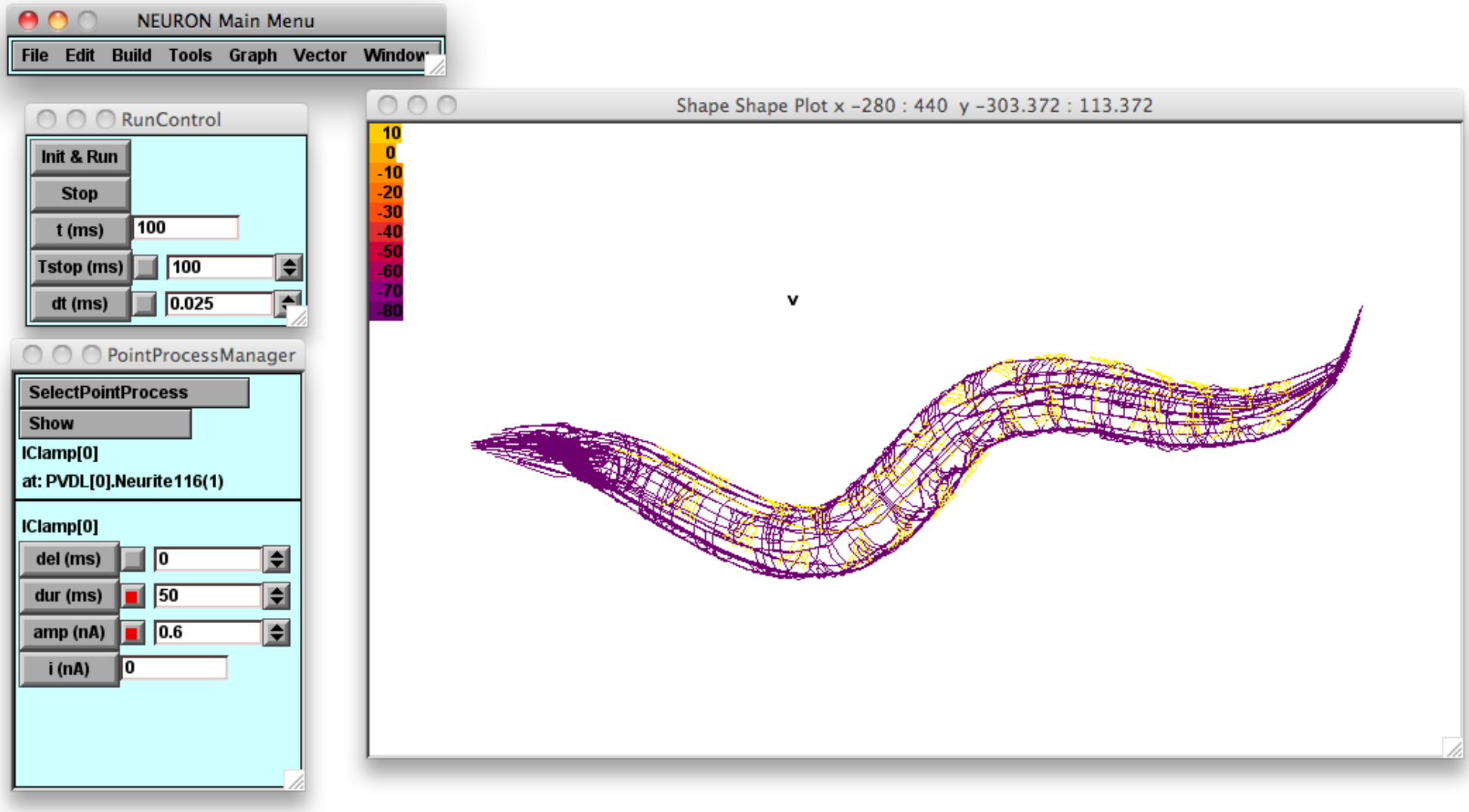
Active for ~18 months

Activities:

- New cloud based simulator integrating physical, electrical & biochemical elements
- More detailed connectome
- Online 3D worm anatomy browser

C. elegans nervous system in NeuroML




NEURON Main Menu
File Edit Build Tools Graph Vector Window
RunControl
Init & Run
Stop
t (ms) 100
Tstop (ms) 100
dt (ms) 0.025
PointProcessManager
SelectPointProcess
Show
IClamp[0]
at: PVDL[0].Neurite116(1)
IClamp[0]
del (ms) 0
dur (ms) 50
amp (nA) 0.6
i (nA) 0
Shape Shape Plot x -280 : 440 y -303.372 : 113.372
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-70
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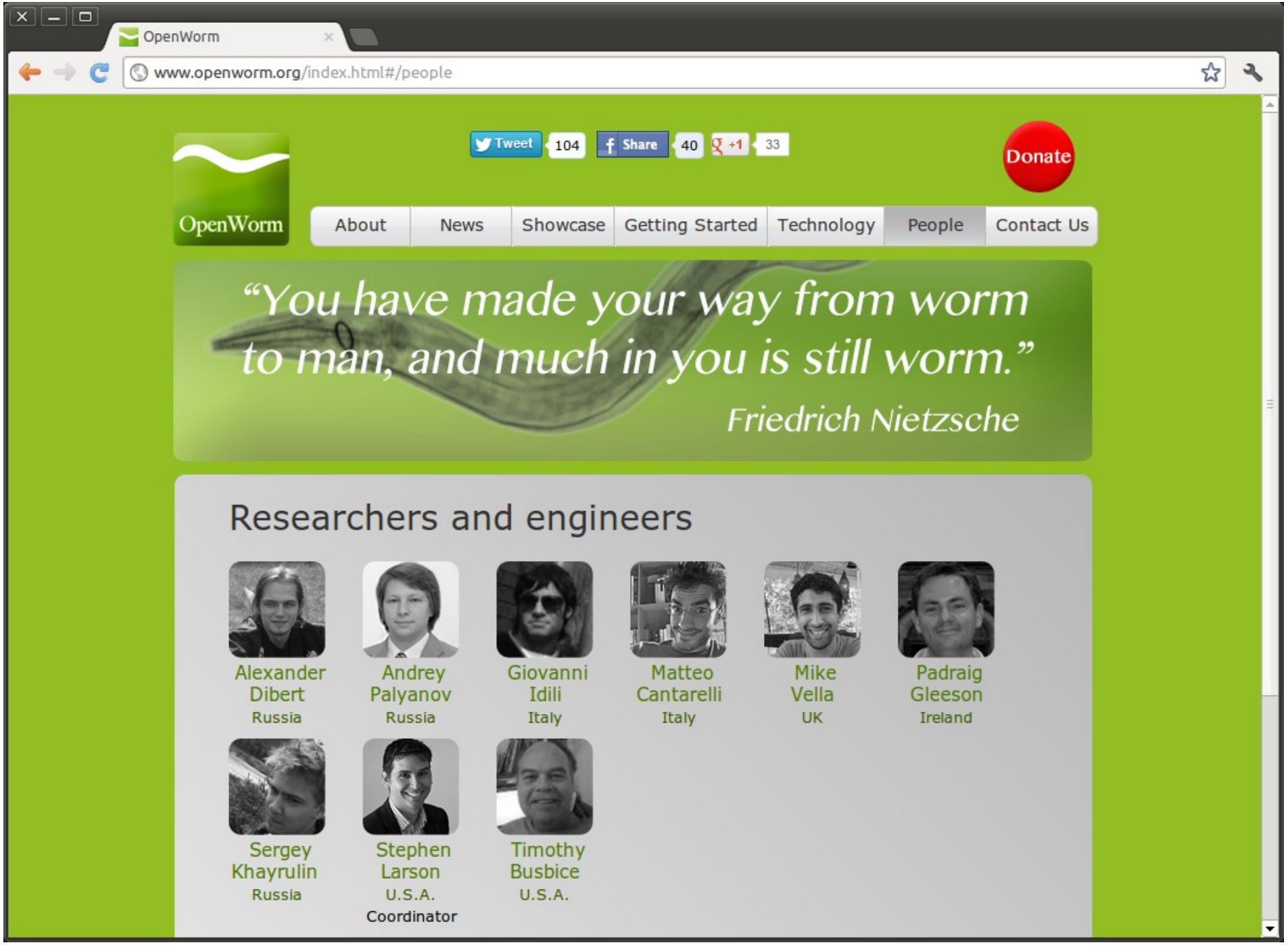
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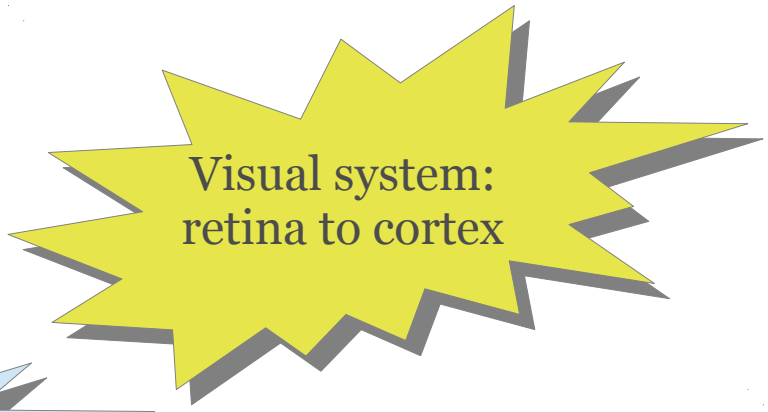
"You have made your way from worm to man, and much in you is still worm."
Friedrich Nietzsche
Researchers and engineers
Alexander Dibert
Russia
Andrey Palyanov
Russia
Giovanni Idili
Italy
Matteo Cantarelli
Italy
Mike Vella
UK
Padraig Gleeson
Ireland
Sergey Khayrulin
Russia
Stephen Larson
U.S.A.
Coordinator
Timothy Busbice
U.S.A.

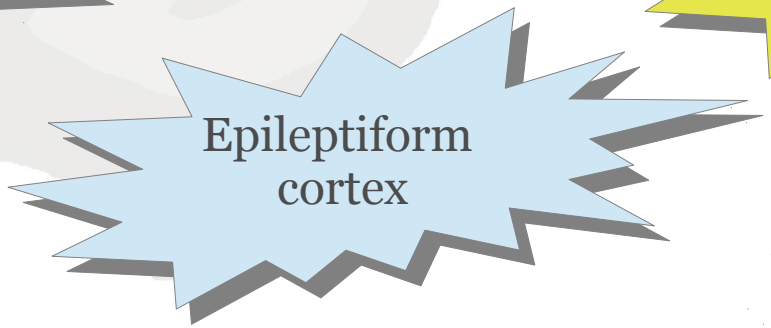
Vision...

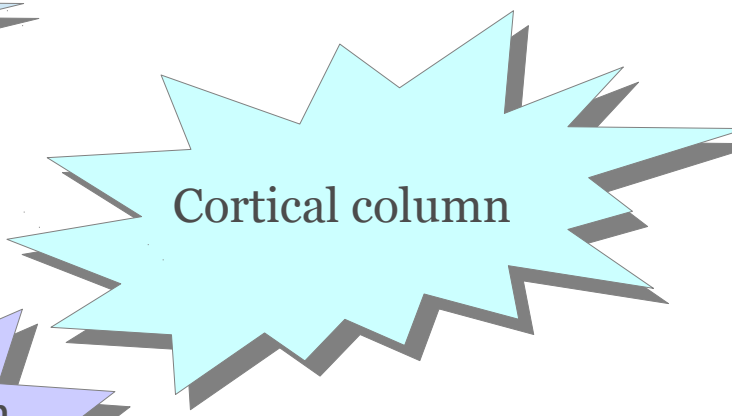
What's the ultimate goal of the OSB initiative?

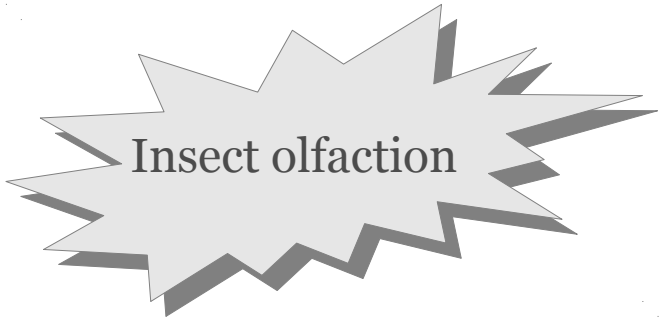
Collaborative modelling in 3-5 years...

Well tested models actively worked on by self organising groups worldwide:

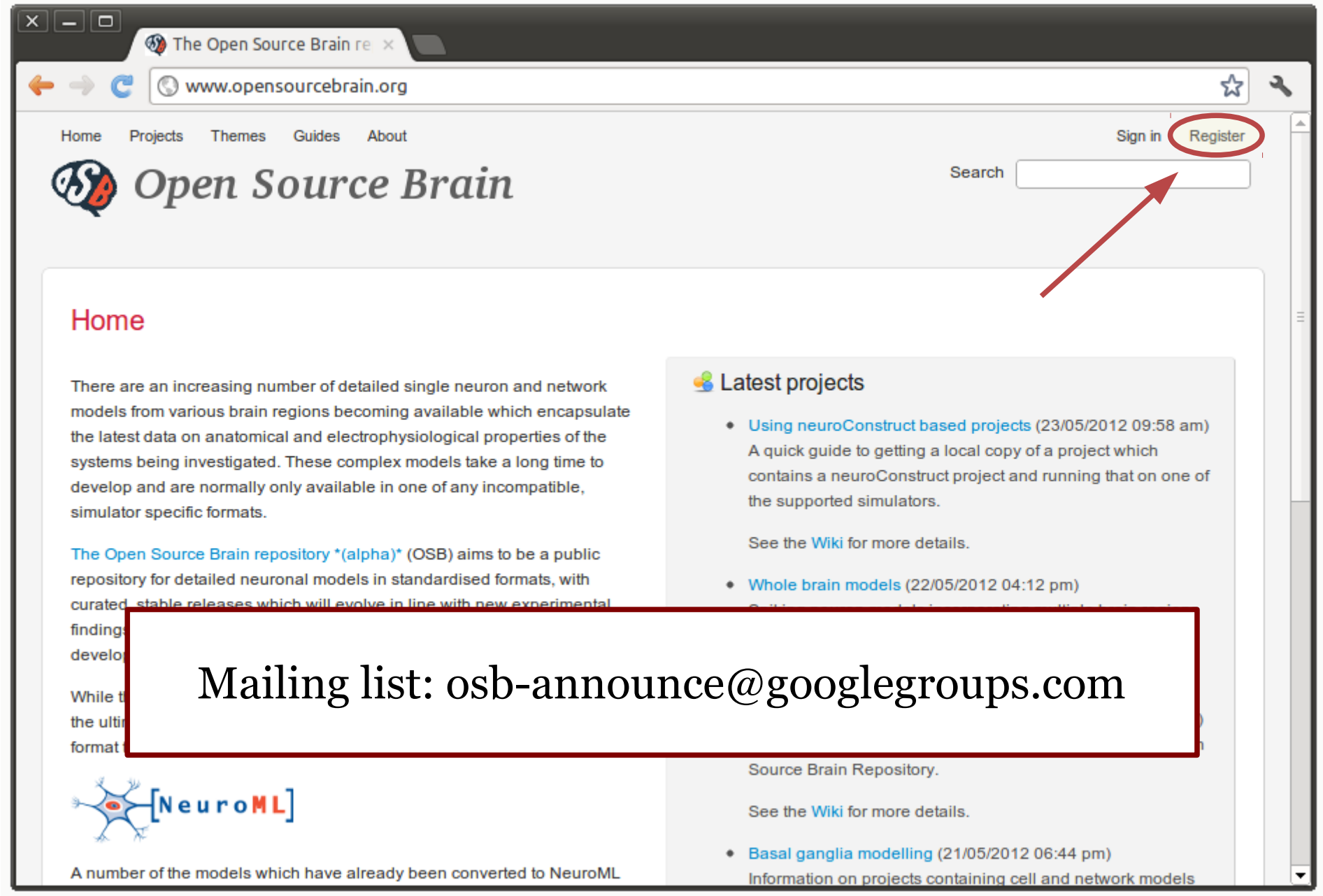








An invitation...



Mailing list: osb-announce@googlegroups.com

Acknowledgements

Silver Lab @ UCL

Angus Silver
Eugenio Piasini
Yates Buckley
Matteo Farinella

Main Collaborators

Robert Cannon
Sharon Crook

Early Adopters/Testers

Sergio Solinas
Egidio D'Angelo
Volker Steuber
Dieter Jaeger
Andrew Davison
Stephen Larson
Avrama Blackwell
Nicolas Le Novere

Members of the NeuroML community

UK INCF Node

Funding source:

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