

A Framework For Model Validation

Shailesh Appukuttan

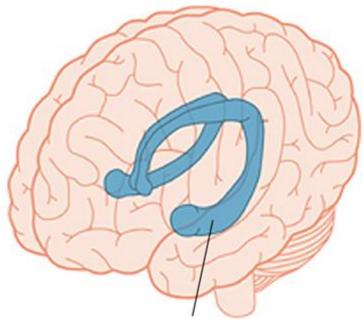
UNIC, CNRS Gif-sur-Yvette, France



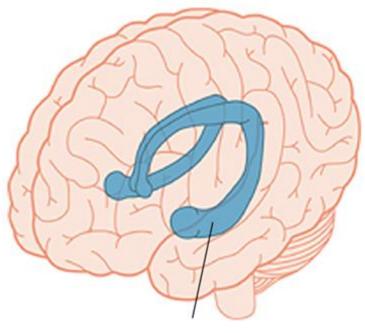
CodeJam #9: Palermo, 26th November 2018



Scenario 1

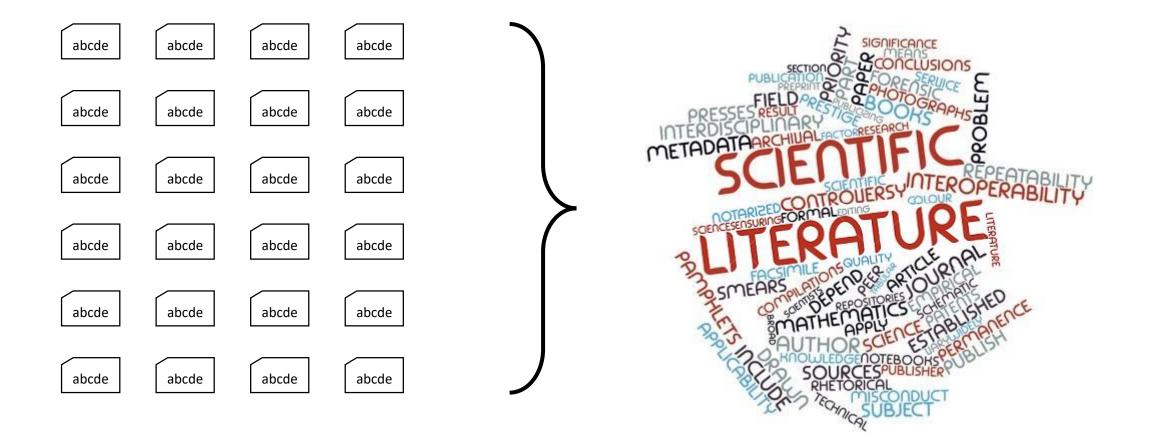


Hippocampus

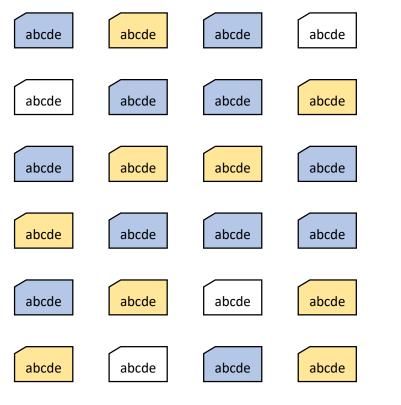


Hippocampus



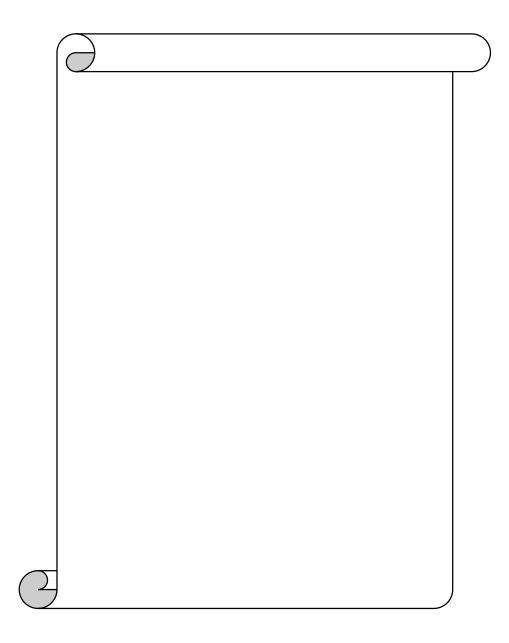


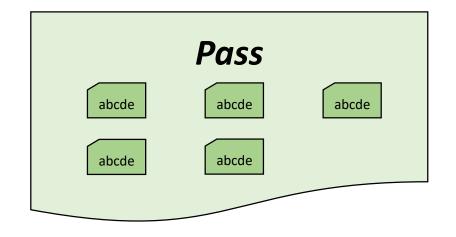
Model Development

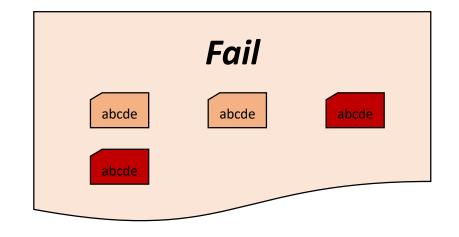


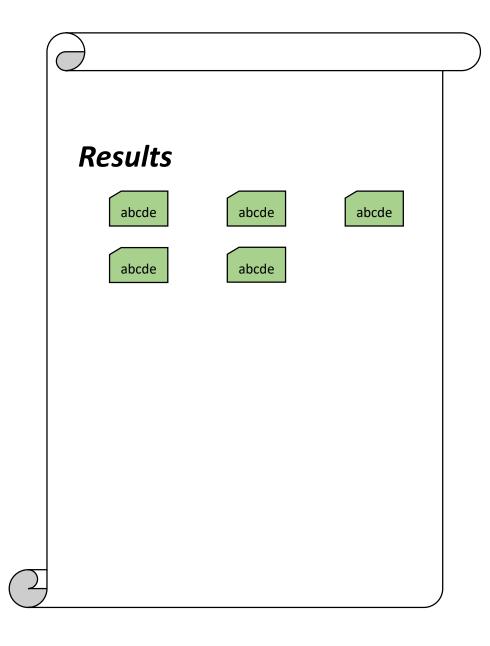
Model Testing

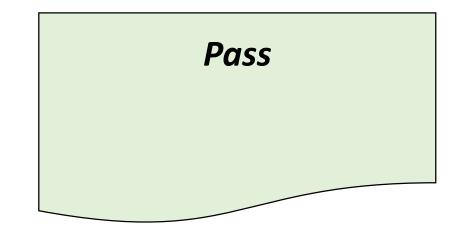


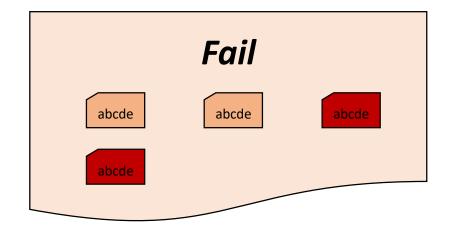


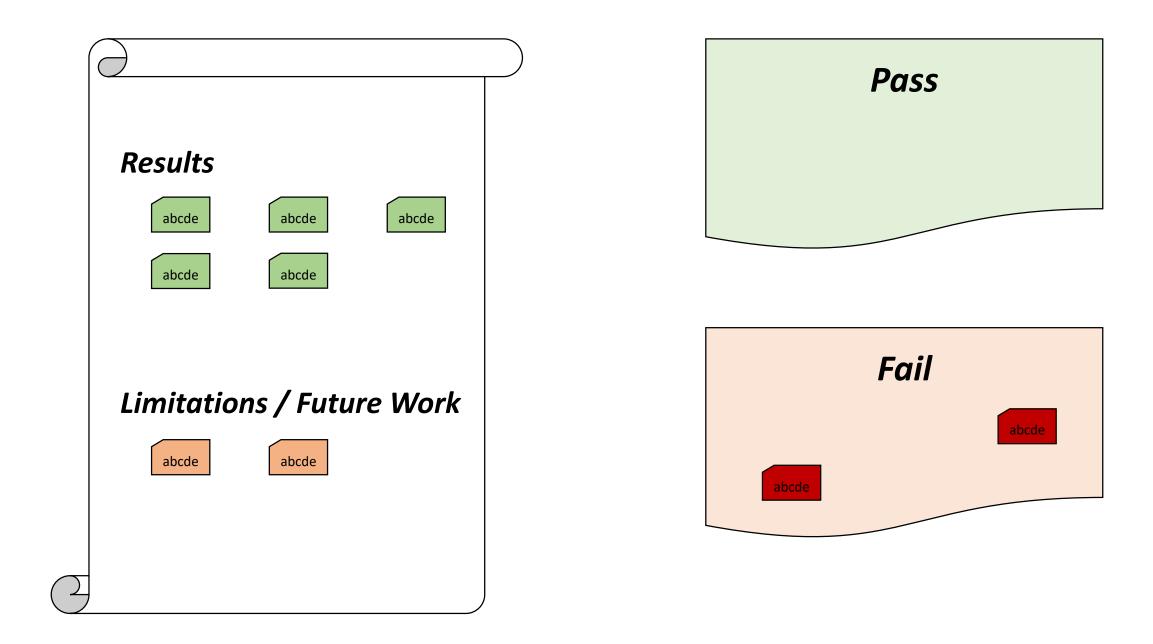










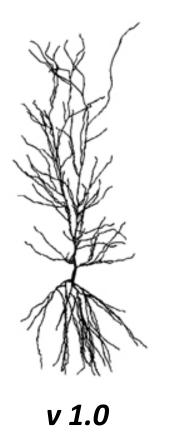


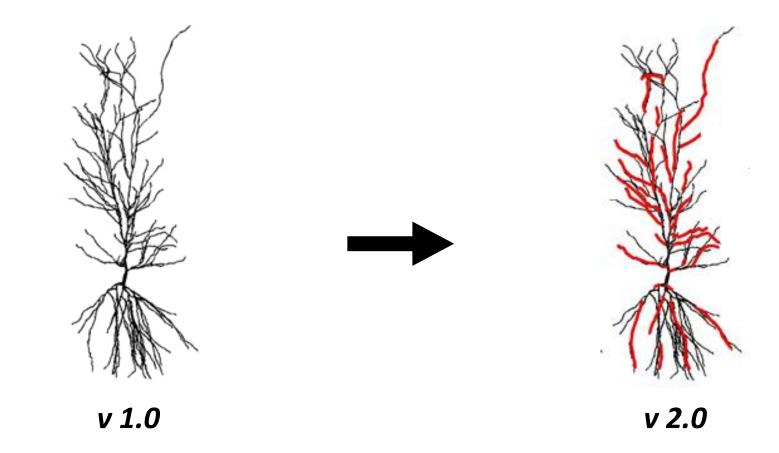
Results		
abcde	abcde	abcde
abcde	abcde	
Limitatio	ns / Futu	ire Work
abcde	abcde	



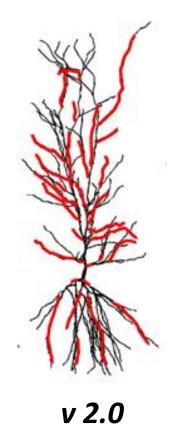
Reviewer

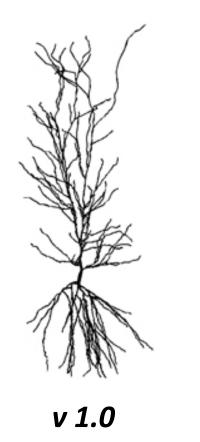
Scenario 2

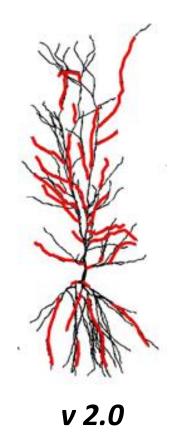








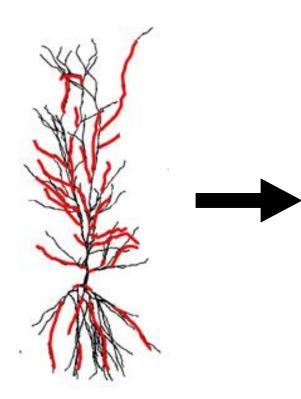


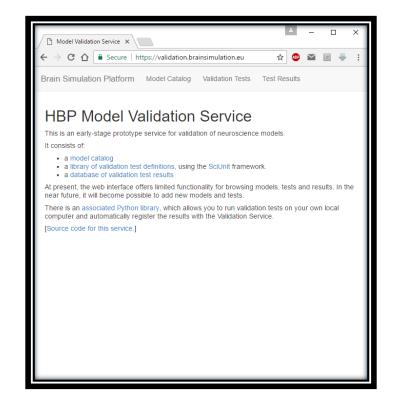




(work in progress) Validation Framework

Validation Framework





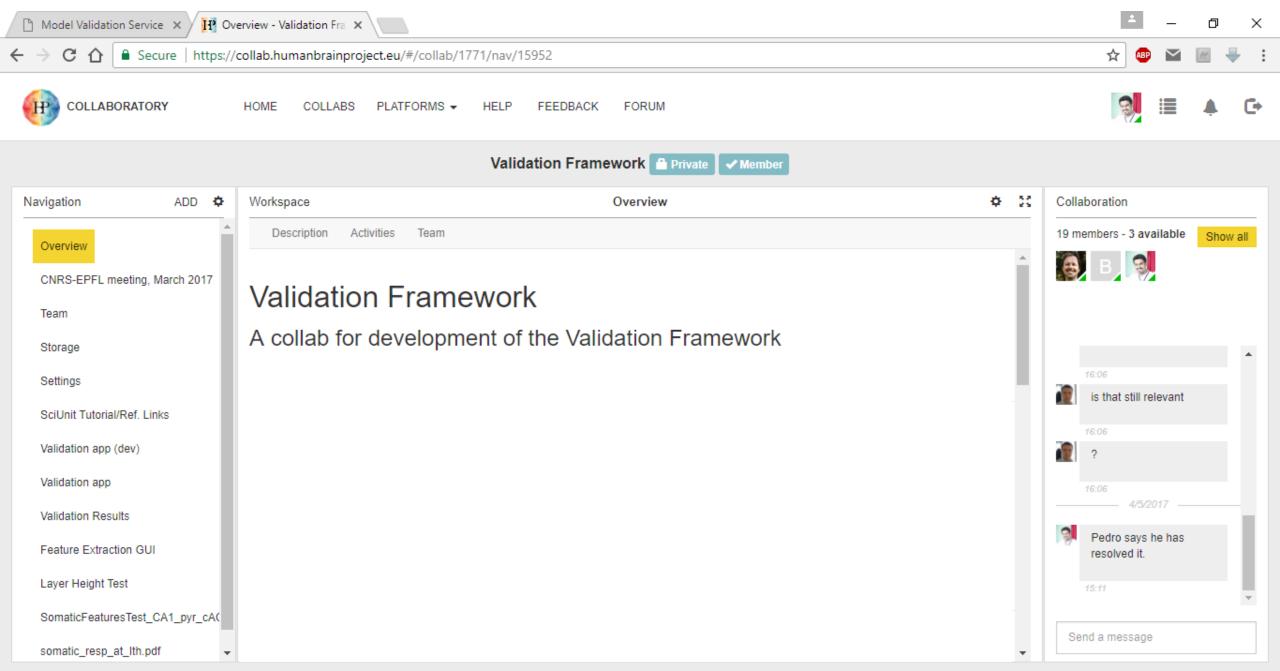
Species: Rat

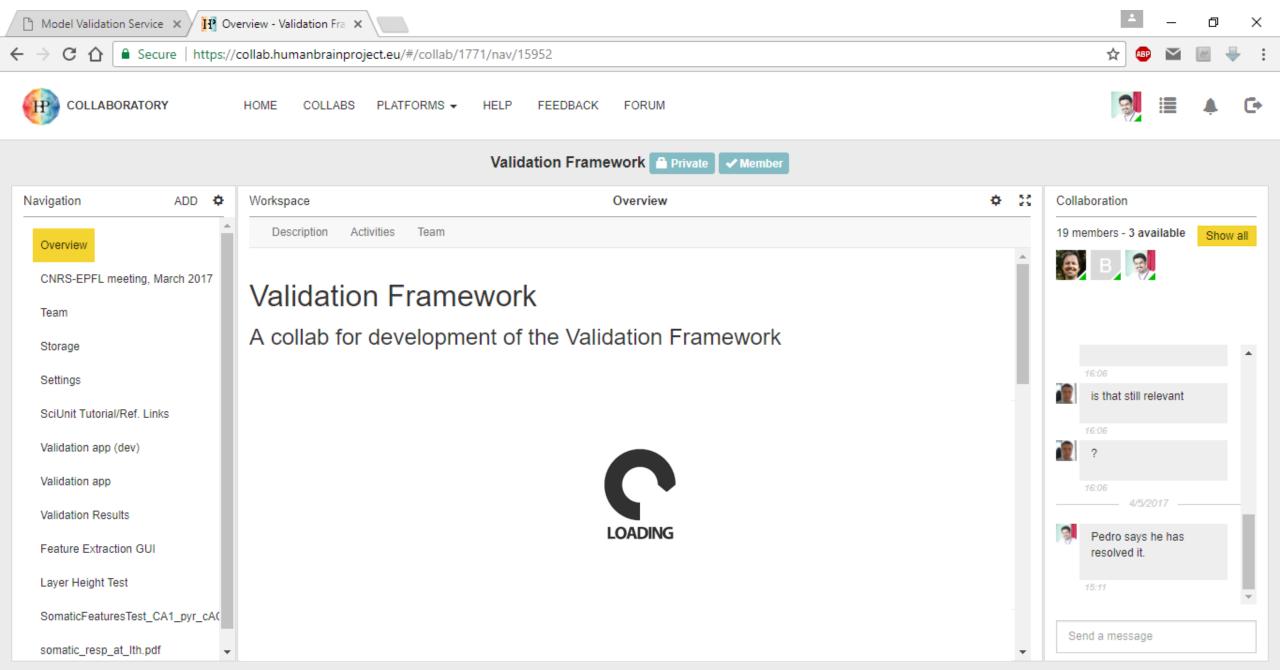
Region: Hippocampus CA1

Cell Type: Pyramidal Cell

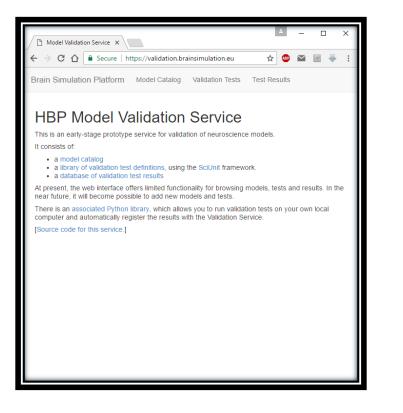
Age: 8-12 Weeks

Test type: Electrical Activity



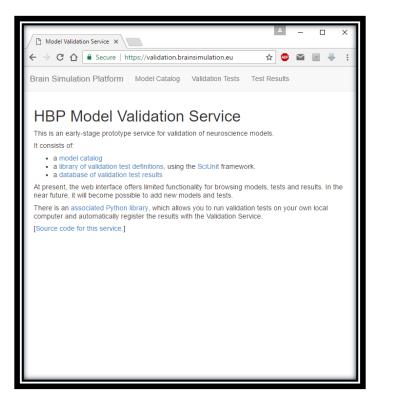


Validation Framework



Test Name	Score	Result
Resting Membrane Potential	0.01	Pass
Input Resistance	0.20	Pass
Action Potential Height	0.05	Pass
Oblique Integration	4.73	Fail
Spiking Frequency	0.15	Pass
Depolarization Block	2.87	Fail
•		
•		

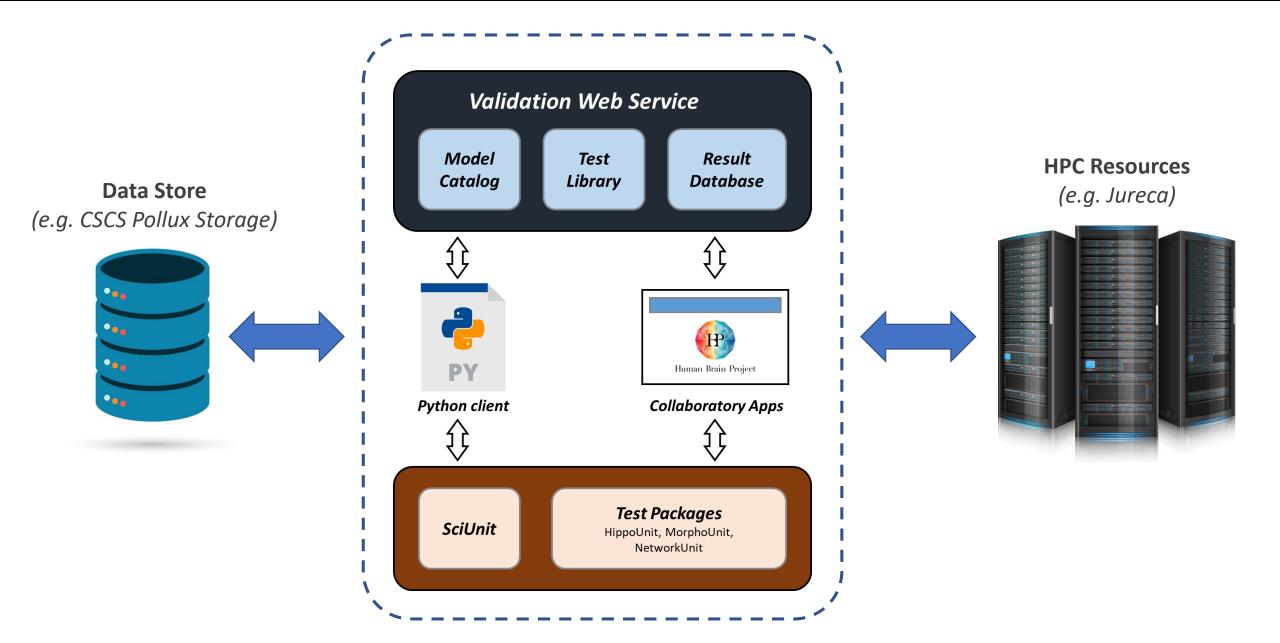
Validation Framework



Model Name	Net Score	Tests Passed
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
	•	
	•	

How It Works... The Finer Details

Validation Framework – Various Components



✓ What is SciUnit?

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

✓ What is SciUnit?

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

✓ What are Tests?

✓ 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 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

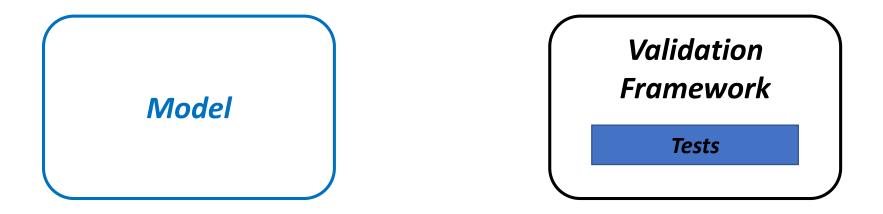
✓ What is SciUnit?

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

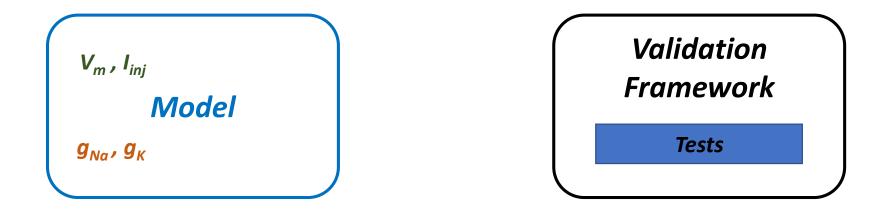
✓ What are Tests?

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

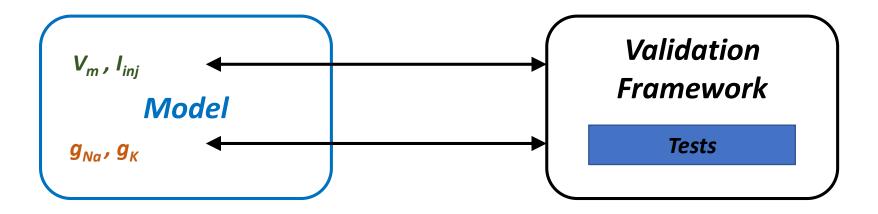
- *interfaces through which the model and the validation framework communicate*
- *implemented as methods (functions) within the model*



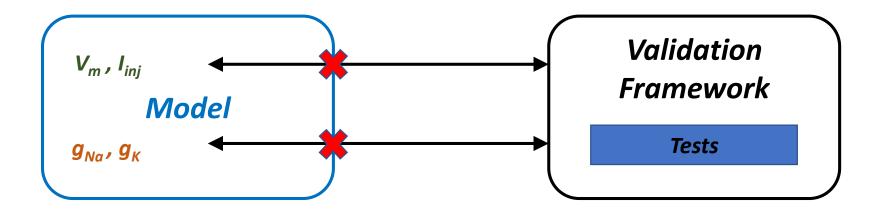
- interfaces through which the model and the validation framework communicate
- implemented as methods (functions) within the model



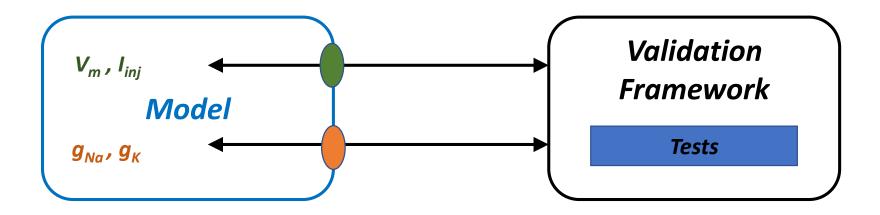
- *interfaces through which the model and the validation framework communicate*
- implemented as methods (functions) within the model



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



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



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

Use of Capabilities

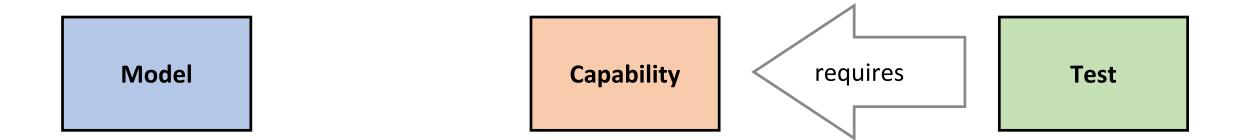
Use of Capabilities

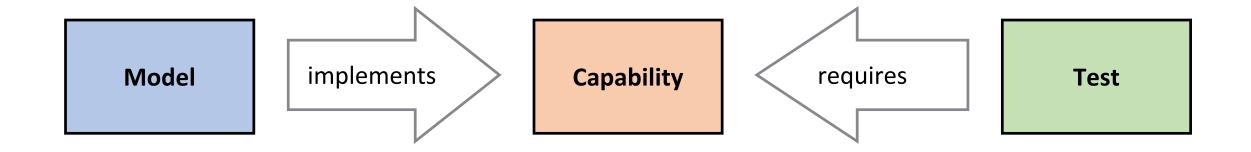
Model

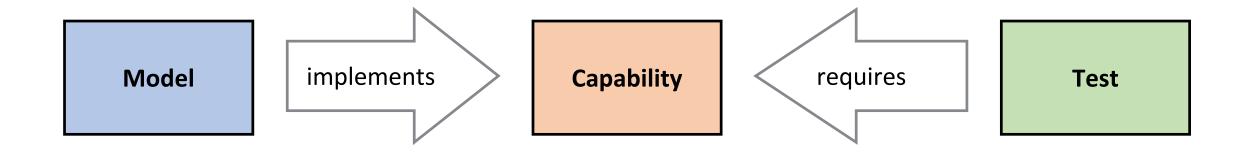
Use of Capabilities

Model

Test

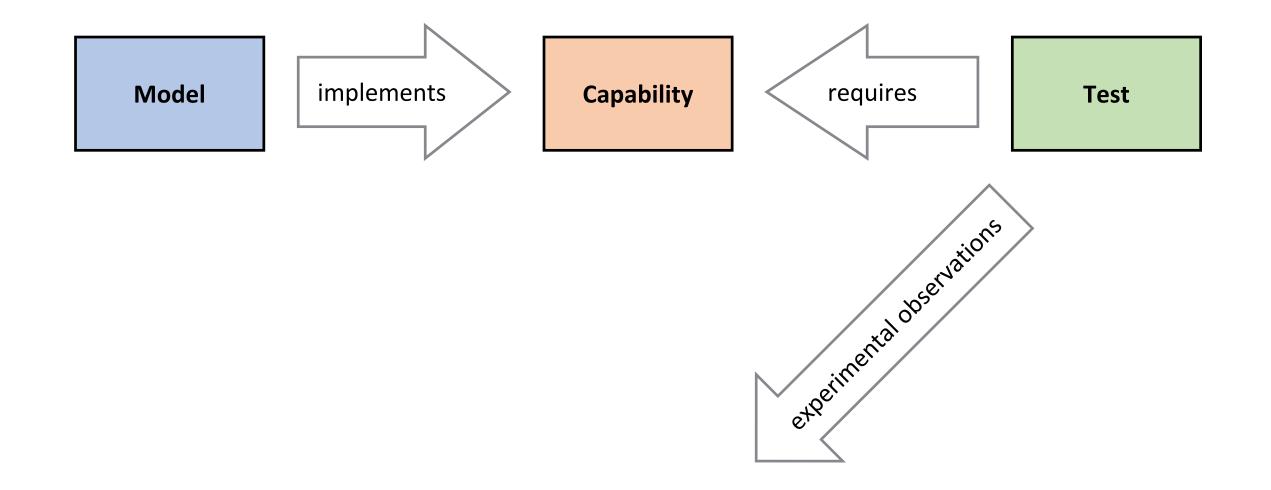


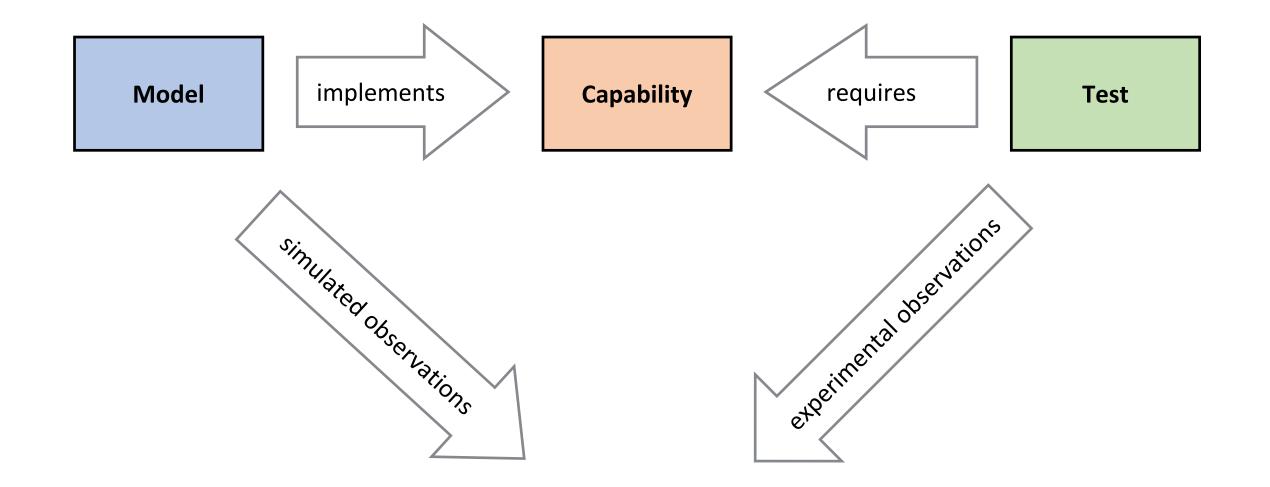




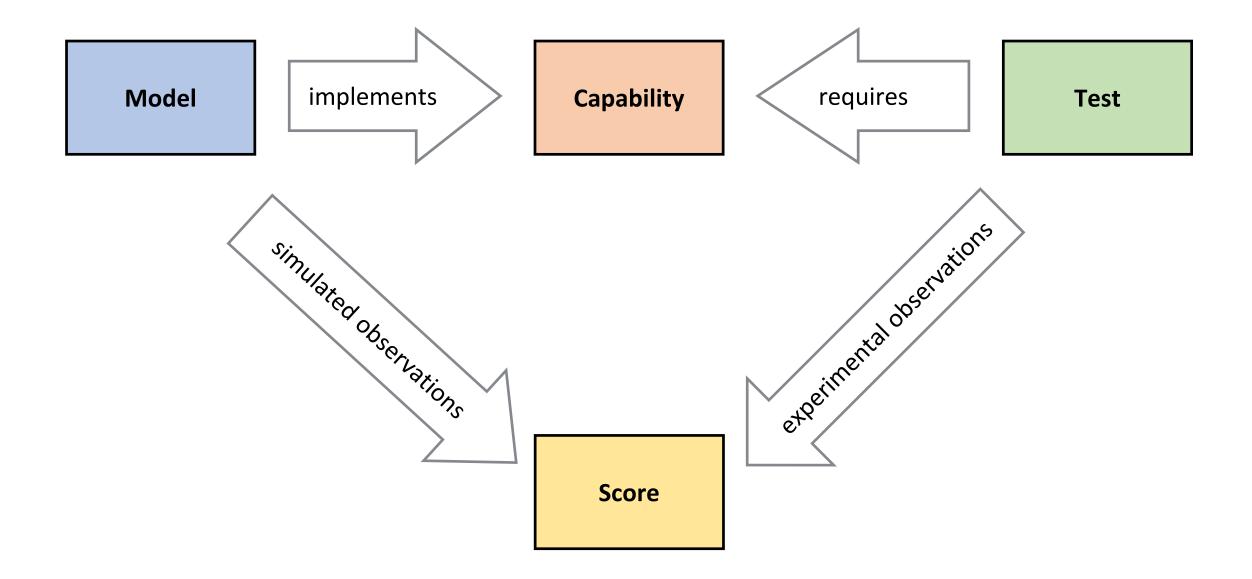
Motivation for using capabilities:

- ✓ decoupling of the validation test implementation from the model implementation
- ✓ a standardized interface between models and tests

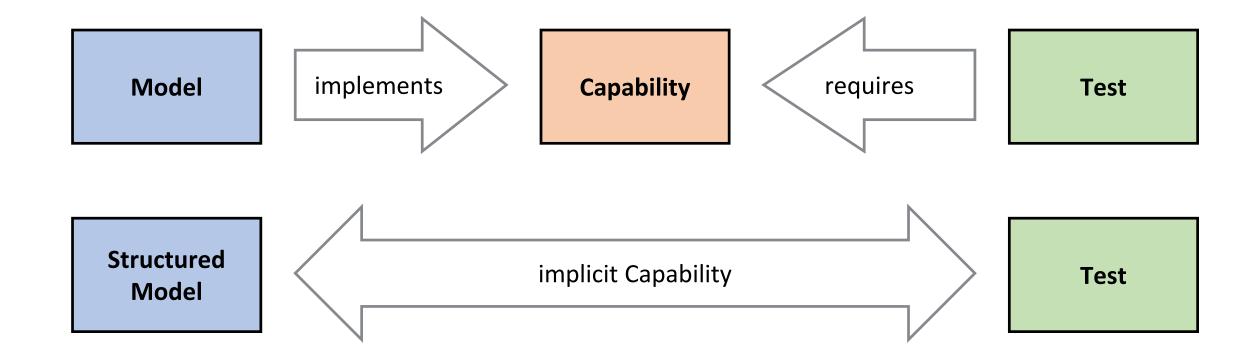


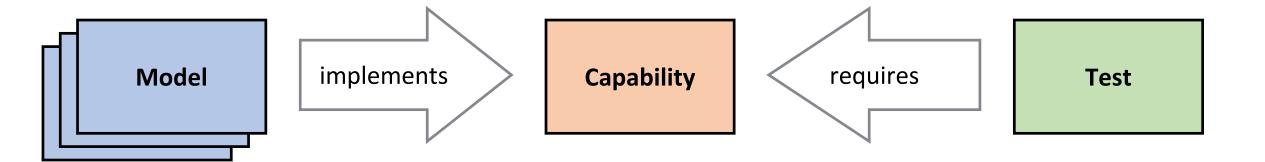


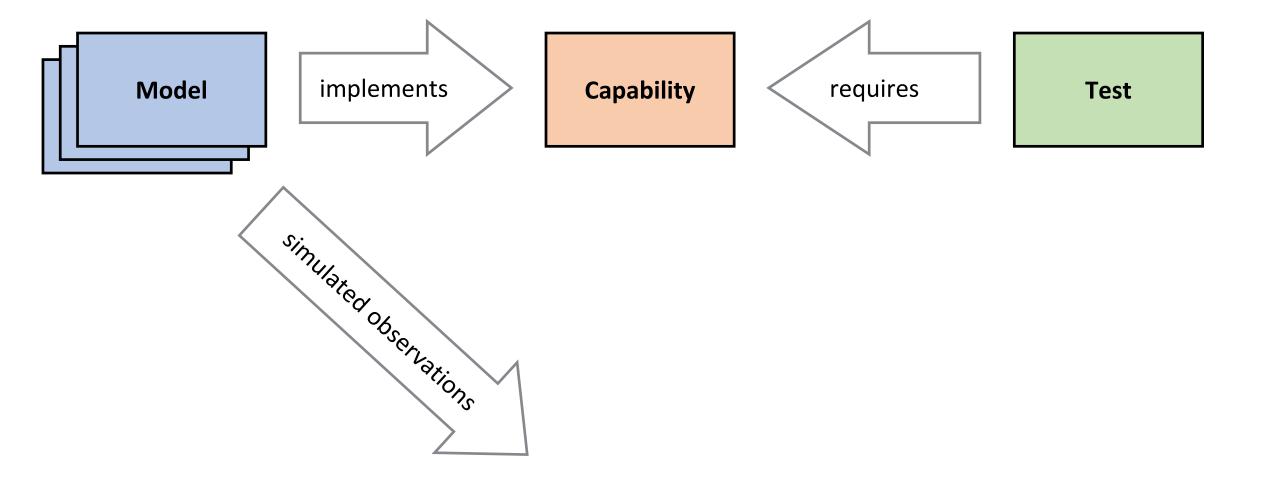
Courtesy: Andrew Davison

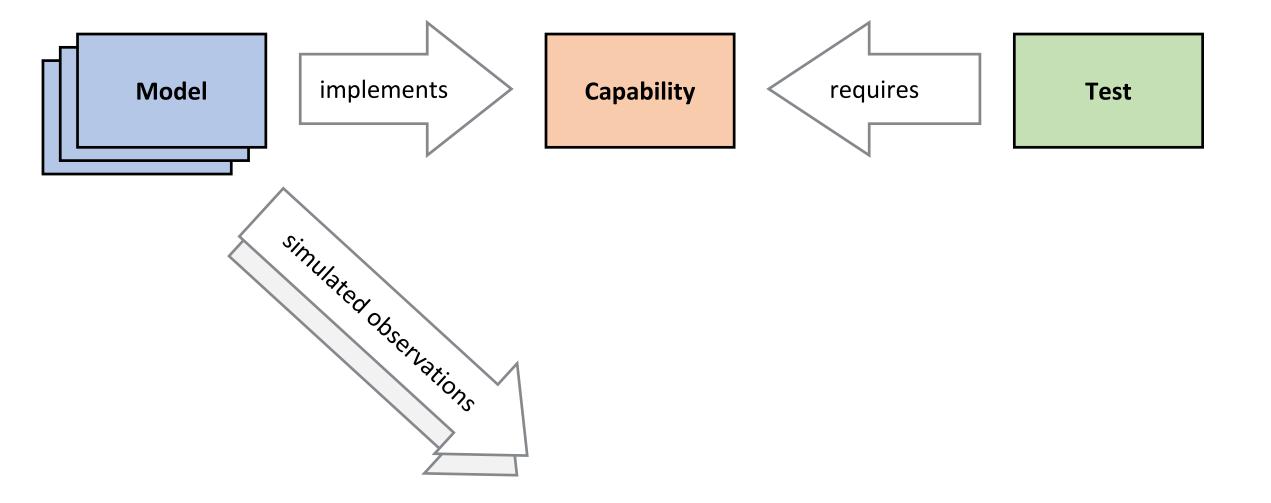


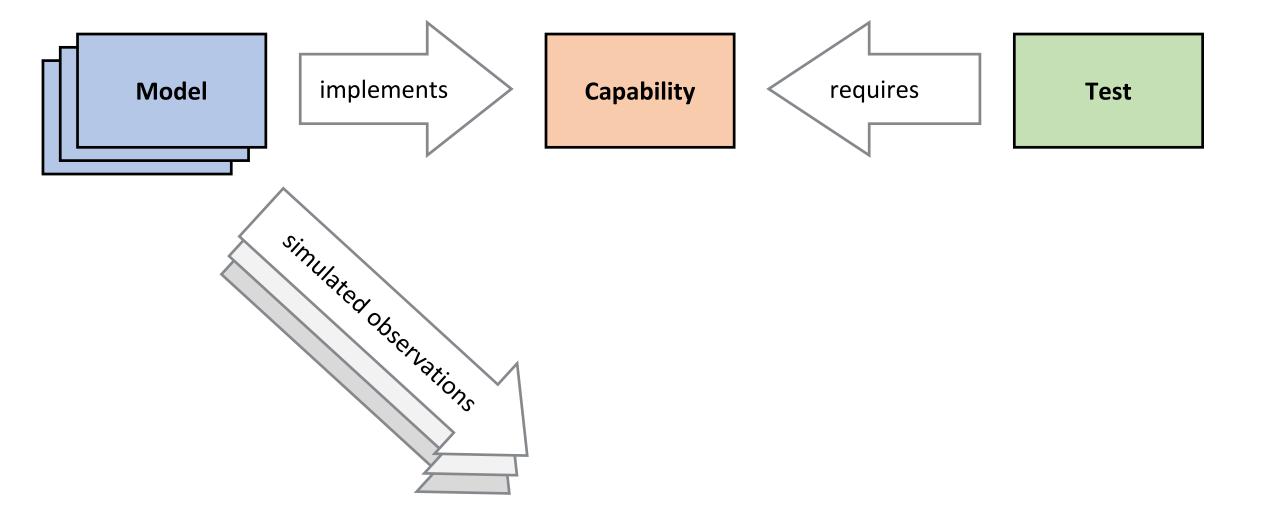
Support for Structured Models

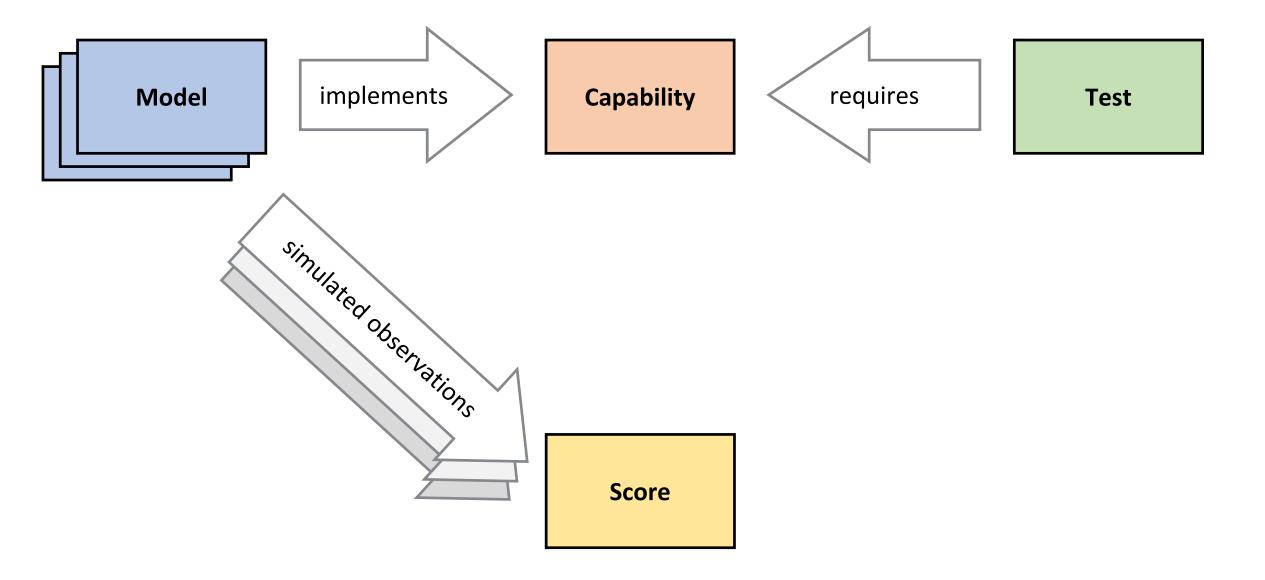












Test Modules

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:

Gamma Somatic Features Test

Experimental data: Migliore et al. 2018

Depolarization Block Test

Experimental data: Bianchi et al. 2012

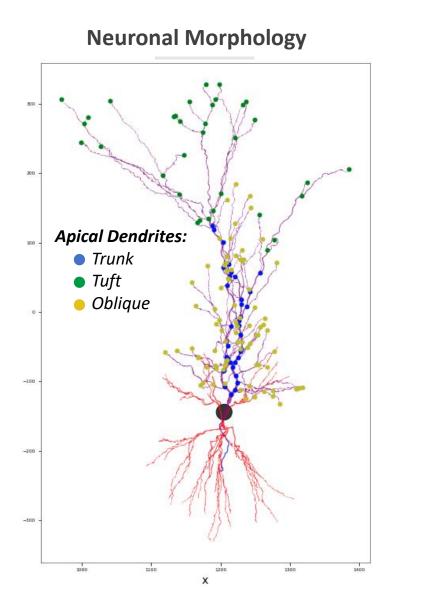
- Backpropagating Action Potential (AP) Test
 Experimental data: Golding et al. 2001
- Post-Synaptic Potential (PSP) Attenuation Test Experimental data: Magee & Cook 2000

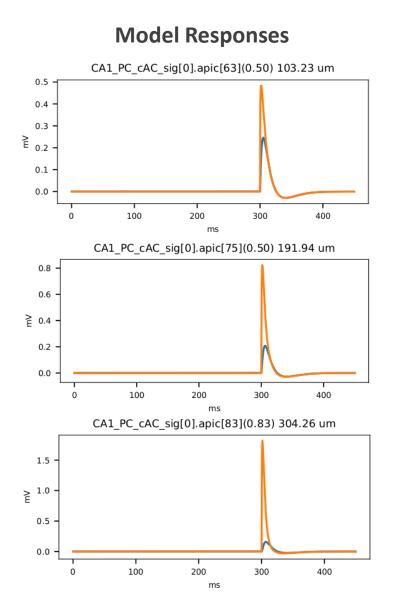
Oblique Integration Test

Experimental data: Losonczy & Magee 2006

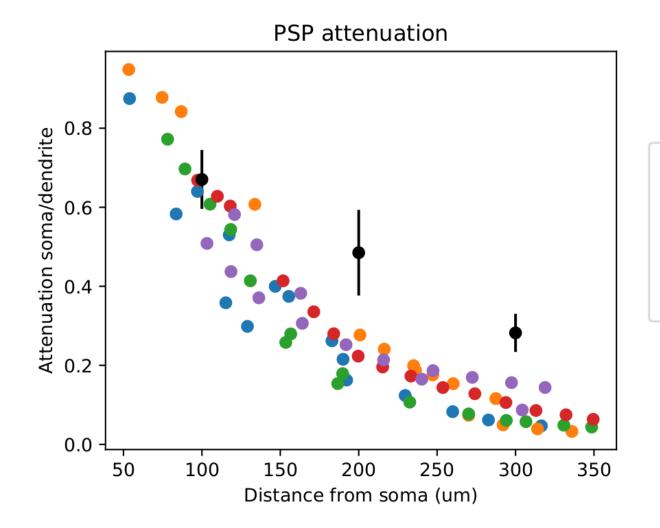
Developed by Sára Saray and Szabolcs Káli (IEM, HAS)

Post-Synaptic Potential (PSP) Attenuation Test



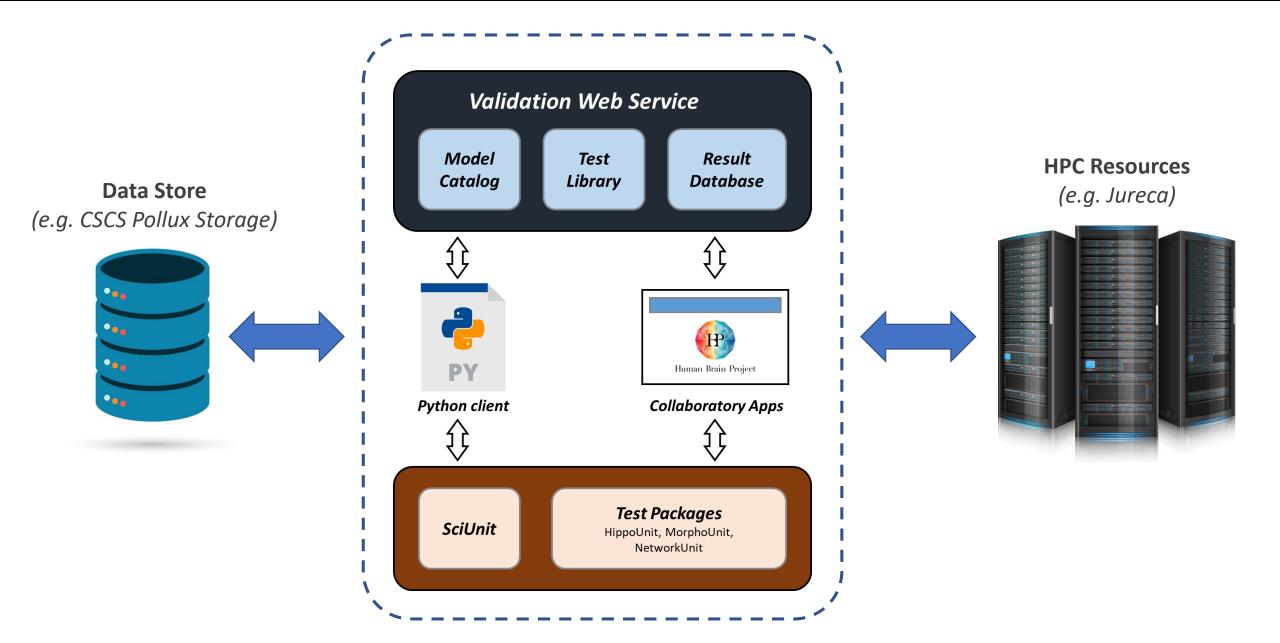


Post-Synaptic Potential (PSP) Attenuation Test



- CA1_pyr_cACpyr_oh140807_A0_idG_20170915113354
- CA1_pyr_cACpyr_oh140807_A0_idH_20170915113422
- CA1_pyr_cACpyr_oh140807_A0_idF_20171003112912
- CA1_pyr_cACpyr_oh140807_A0_idJ_20170915113621
- CA1_pyr_cACpyr_oh140807_A0_idC_20170912112759
- Experimental data (Magee & Cook, 2000)

Validation Framework – Various Components



Model Catalog App

Workspace						Model Cat	alog				
	Model Catalog										
Select:	species 🕶	Hippocampus 🗸	cell type 🗸	model scope -	abstraction le	evel - Selec	ct organization 🕶	Select privacy -	Select collab	• Nev	w model
Search:											
Name				Species	Brain region	Cell type	Model scope	Author(s)	Organization	Collab ID	Privacy
Network	c model 2018030)9		Rat (Rattus rattus)	Hippocampus	Not applicable	Network model	Romani	HBP-SP6	9821	Public
Network	c model 2018021	19		Rat (Rattus rattus)	Hippocampus	Not applicable	Network model	Romani	HBP-SP6	9821	Public
Network	Network model 20170630c			Rat (Rattus rattus)	Hippocampus	Not applicable	Network model	Romani	HBP-SP6	9821	Public
Network	Network model 20170630b			Rat (Rattus rattus)	Hippocampus	Not applicable	Network model	Romani	HBP-SP6	9821	Public
Network	Network model 20160630			Rat (Rattus rattus)	Hippocampus	Not applicable	Network model	Romani	HBP-SP6	9821	Public
Network	c model 2016032	22 (RUP M30)		Rat (Rattus rattus)	Hippocampus	Not applicable	Network model	Romani	HBP-SP6	9821	Public
CA1_py	r_cACpyr_oh14	0807_A0_idJ_201709	15113621	Rat (Rattus rattus)	Hippocampus	Pyramidal Cell	Single cell model	Rosanna Migliore	HBP-SP6	9821	Public
CA1_py	r_cACpyr_oh14	0807_A0_idH_201709	15113422	Rat (Rattus rattus)	Hippocampus	Pyramidal Cell	Single cell model	Rosanna Migliore	HBP-SP6	9821	Public
CA1_py	r_cACpyr_oh14	0807_A0_idG_201709	15113354	Rat (Rattus rattus)	Hippocampus	Pyramidal Cell	Single cell model	Rosanna Migliore	HBP-SP6	9821	Public
CA1_py	r_cACpyr_oh14	0807_A0_idF_201710	03112912	Rat (Rattus rattus)	Hippocampus	Pyramidal Cell	Single cell model	Rosanna Migliore	HBP-SP6	9821	Public
CA1_pyr_cACpyr_oh140807_A0_idC_20170912112759			Rat (Rattus rattus)	Hippocampus	Pyramidal Cell	Single cell model	Rosanna Migliore	HBP-SP6	9821	Public	
CA1_pyr_cACpyr_oh140807_A0_idB_20170915112605			Rat (Rattus rattus)	Hippocampus	Pyramidal Cell	Single cell model	Rosanna Migliore	HBP-SP6	9821	Public	

Model Catalog App



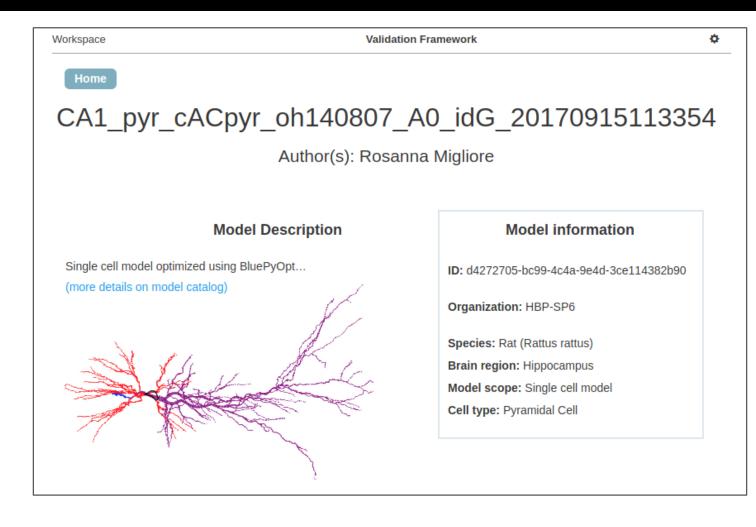
Model Versions						
Name	D	Created on				
1.0	e1ee5736-7a29-42a6-aa1e-1ea56127c7d5	29/03/2018, 02:23				
Description:						
Parameters:						
Morphology	["https://object.cscs.ch/v1/AUTH_c0a333ecf7c045809321ce9 ∢	d9ecdfdea/Migliore_2018_CA1/# View morphology				
Code format:	asc, py, hoc, mod, json					
Download location:	https://object.cscs.ch/v1/AUTH_c0a333ecf7c045809321ce9d9ecdfd	ea/hippocampus_optimization/optimizations/CA1_pyr_cACpyr_ot				

Model Catalog App – Morphology Viewer

Readme Terms of use What's new Feedback							
Select neuron from O my computer NeuroMorpho.org Allen Cell Types I HBP Model Catalog							
Model instance: e1ee5736-7a29-42a6-aa1e-1ea56127c7d5 V							
Load neuron: CA1_pyr_cACpyr_oh140807_A0_idG_20170915113354, item 0: oh140807_A0_idG.asc ▼							
Meta data at the <u>HBP Model Catalog</u> .							
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	MK KK						
[+] SP/SO							
[+] SO/ALV	The second secon						
[+] HF/SLM	and the second sec						
[-]							
Points (49)							
[-] 🖉 Axon	A A A A A A A A A A A A A A A A A A A						
Attributes (8) > Points (47) >							
[-] 🕑 dendrites							
[+] 🗹 (basal) Dendrite #1							
[+] 🗹 (basal) Dendrite #2							
[+] 🗹 (basal) Dendrite #3							
[+]							
[+] C Apical dendrite							
4							
Spatial registration							
The neuron currently has its coordinates in the <i>local</i> spatial reference system.							

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

Validation Results App – By Model



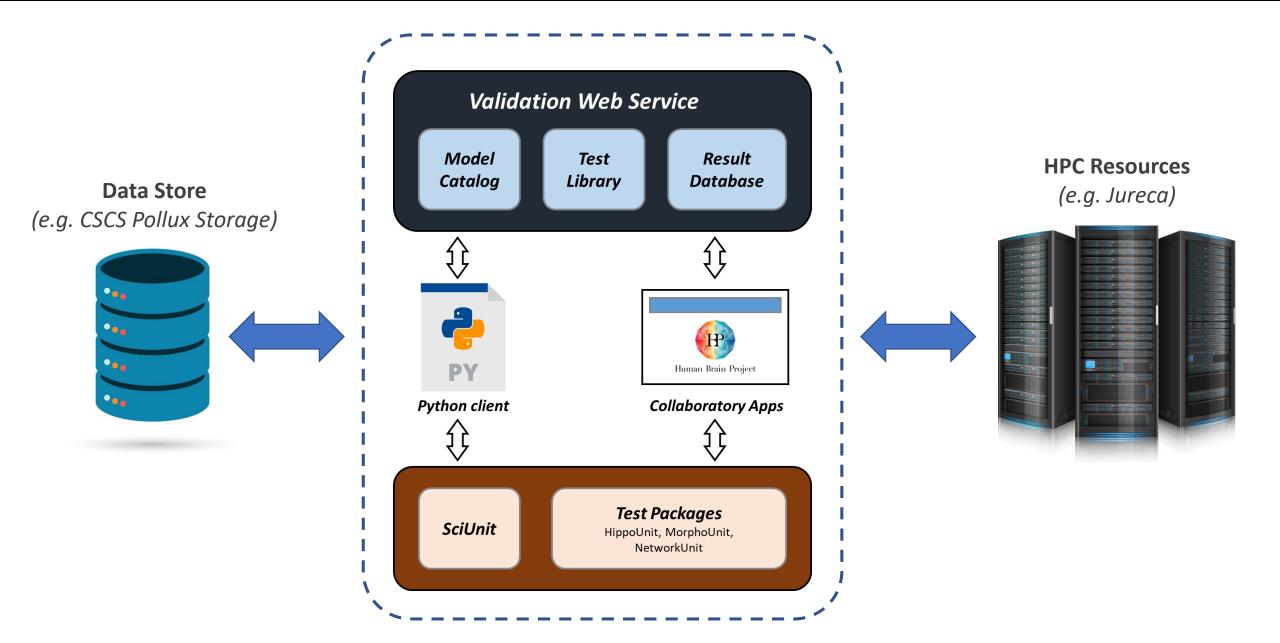
Validation Results App – By Model

Wor	rkspace Validation	Framework	٥
	Home		
C	A1_pyr_cACpyr_oh140807_A	\0_idG_2017091511335	54
	Author(s): Rosann	a Migliore	
	Model Description	Model information	
	Single cell model optimized using BluePyOpt	ID: d4272705-bc99-4c4a-9e4d-3ce114382b90	
(more details on moder catalogy	Organization: HBP-SP6	
	Re	sults	
	test id model version	1.0	
		score date	
	Backpropagating Action Potential Test (1.0)	8.2057 23/10/2018, 04:45	
	Post-Synaptic Potential Attenuation Test (1.0)	2.9428 23/10/2018, 04:36	
	Somatic Features Test (1.0)	1.0828 23/10/2018, 04:32	
	Depolarization Block Test (1.0)	6.2567 23/10/2018, 04:24	

Validation Results App – By Test

Vorkspace	Validation	n Framew	ork		٥	
Hippocampus_CA1_PSPAttenuationTest Author(s): Sara Saray						
Description	Version	R	Results	Comments		
	Res	sults				
model id test v	ersion		1.0			
			score	date		
CA1_pyr_cACpyr_oh140	807_A0_idC_201709121127	759 (1.0)	2.5555	23/10/2018, 05:57		
CA1_pyr_cACpyr_oh140	807_A0_idF_201710031129	912 (1.0)	2.7258	23/10/2018, 05:22		
CA1_pyr_cACpyr_oh140	807_A0_idG_20170915113	354 (1.0)	2.9428	23/10/2018, 04:36		
CA1_pyr_cACpyr_oh140	807_A0_idH_201709151134	422 (1.0)	2.9059	23/10/2018, 03:50		
CA1_pyr_cACpyr_oh140	807_A0_idJ_201709151136	21 (1.0)	2.0832	23/10/2018, 01:08		

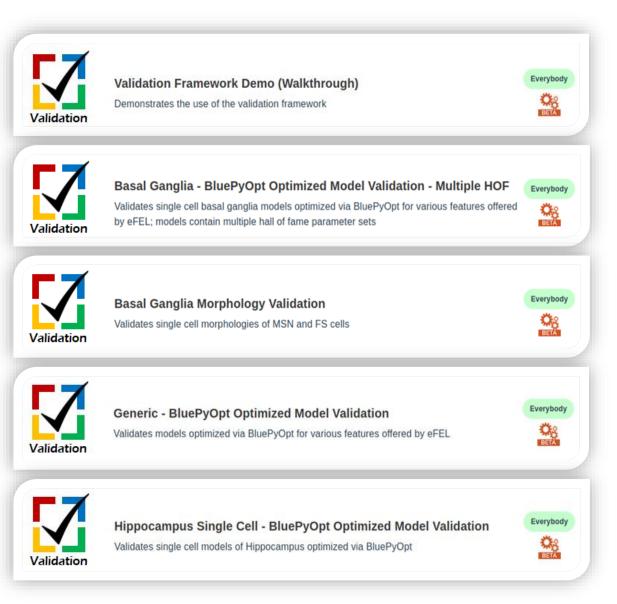
Validation Framework – Various Components



Use Cases on Brain Simulation Platform

- The Brain Simulation Platform provides an array of tools and services assisting data-driven model development
- Freely available to the scientific community
- The platform hosts several Use Cases that enable users to employ various established validation workflows
- Customizable by allowing the user to configure parameters as per requirements

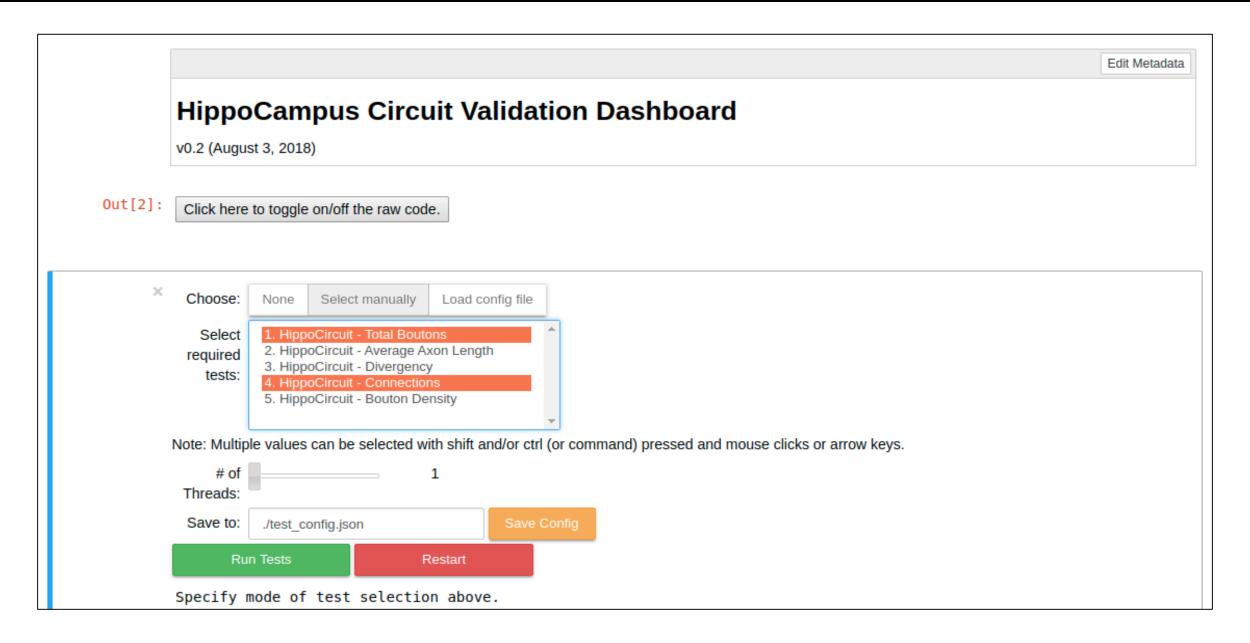
Thanks to **Alexander Dietz** and **Stefano Antonel** (EPFL) for their support on this task.



REST API & Python Client

$\leftarrow \rightarrow \mathbf{C}$ \triangleq Secure h	ttps://github.com/HumanBrainProj	ec 🍳 🖈 🖪 🖡 🗣 🛞 🔣	← → C 🔒 Secure ht	t ps://github.com/ HumanBrainPro	jec Q 🖈 🖪 🖡 🌢 🚷 🔛		
Code Issues 35	validation-framework Pull requests o 🔲 Projects o 📾 Wik	Ounwatch → 6 ★ St Ki Insights Settings	Image: Second state of the second s	lidation-client Il requests o 🖳 Projects o 닖 Insi	Ounwatch → 8 ★ Sta ights Image: Settings		
No description, website, or topics	s provided.		A Python package for working with Manage topics	the Human Brain Project Model Validat	tion Framework http://hbp-validation-client.re		
⑦ 989 commits	₽ 2 branches	🛇 0 releases 44 6	203 commits	₽ 1 branch S 1 release	e 🎎 2 contributors 🚓		
Branch: master - New pull request		Create new file Upload files Find file	Branch: master - New pull request		Create new file Upload files Find file		
HFragnaud Merge pull request #226	from HFragnaud/master	Latest co	This branch is 19 commits ahead of a	odavison:master.	l'1 Pull		
.vscode	new depo + first stage test creation		appukuttan-shailesh Merge pull reque	est #33 from appukuttan-shailesh/master	Latest commi		
← → C Secure h	ttps://hbp-validation-framework-ap	i.r Q ☆ 🚺 🖊 🛞 🌉 next routing table index	← → C Secure ht	tps://hbp-validation-client.readth Client 0.4.0 documentation »	ed) 🖈 🚺 🖊 🛞 🎦 modules index		
Table Of Contents Models Model Instances Model Images	Welcome to Validat REST API docume		Table Of Contents HBP Validation Framework - Python Client: Documentation Ouick Overview	HBP Validation Framework - Python Client: Documentation			
Tests Test Instances Results	General Info		General Info Regarding HBP Authentication	A Python package for working with the Human Brain Project Model Validation Framework.			
Miscellaneous Next topic	 Collabs on the HBP Collaboratory can be either public or private. Public Collabs can be accessed by all registered users, whereas private Collabs require the user to be granted permission for access. 		TestLibrary ModelCatalog Utilities This Page	ttan, CNRS, 2017 txt			
Models This Page	-	ation Framework apps can be added to nultiple instances of these ap 🗐 v: latest 💌	Show Source	Quick Overview	Ø v: master ▼		
Show Source	apps require to be configured by	setting the provided filters appropriately ilters restrict the type of data displayed in	Quick search	We discuss here some of the terms us			
Ouick search	that particular instance of the app		60	Model			

Validation Dashboard



Ongoing Work & Future Plans

- Continue developing a comprehensive, test repository for models covering a variety of biophysical features
- Creating test suites; will help avoid having to manually specify lists of tests
- Development and release of Validation Dashboard
- Execution of simulations online on HPC resources
- Automated launch of validations when a new model instance is registered
- Integrate BlueNaaS (Neuron as a Service) with the Model Catalog with help from Genrich Ivaska (EPFL)
- Develop appropriate scoring methods for evaluating model performance e.g. sensitivity analysis, quantification of model uncertainty



Grazie!



