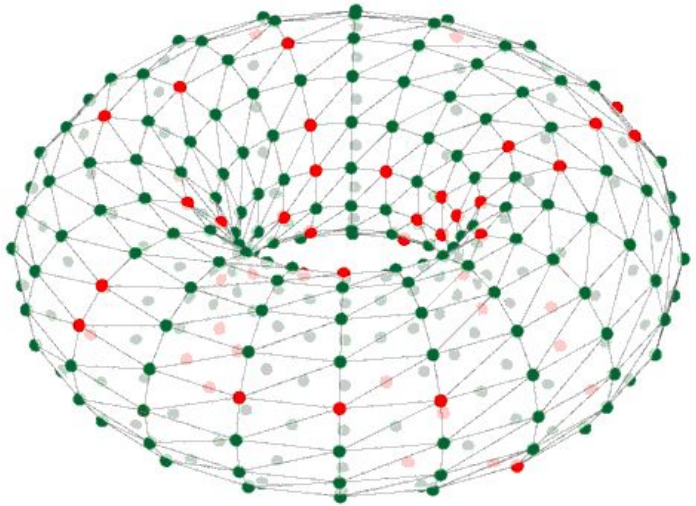
MANCHESTER 1824

SpiNNaker Tutorial



SpiNNaker

MANCHESTER 1824

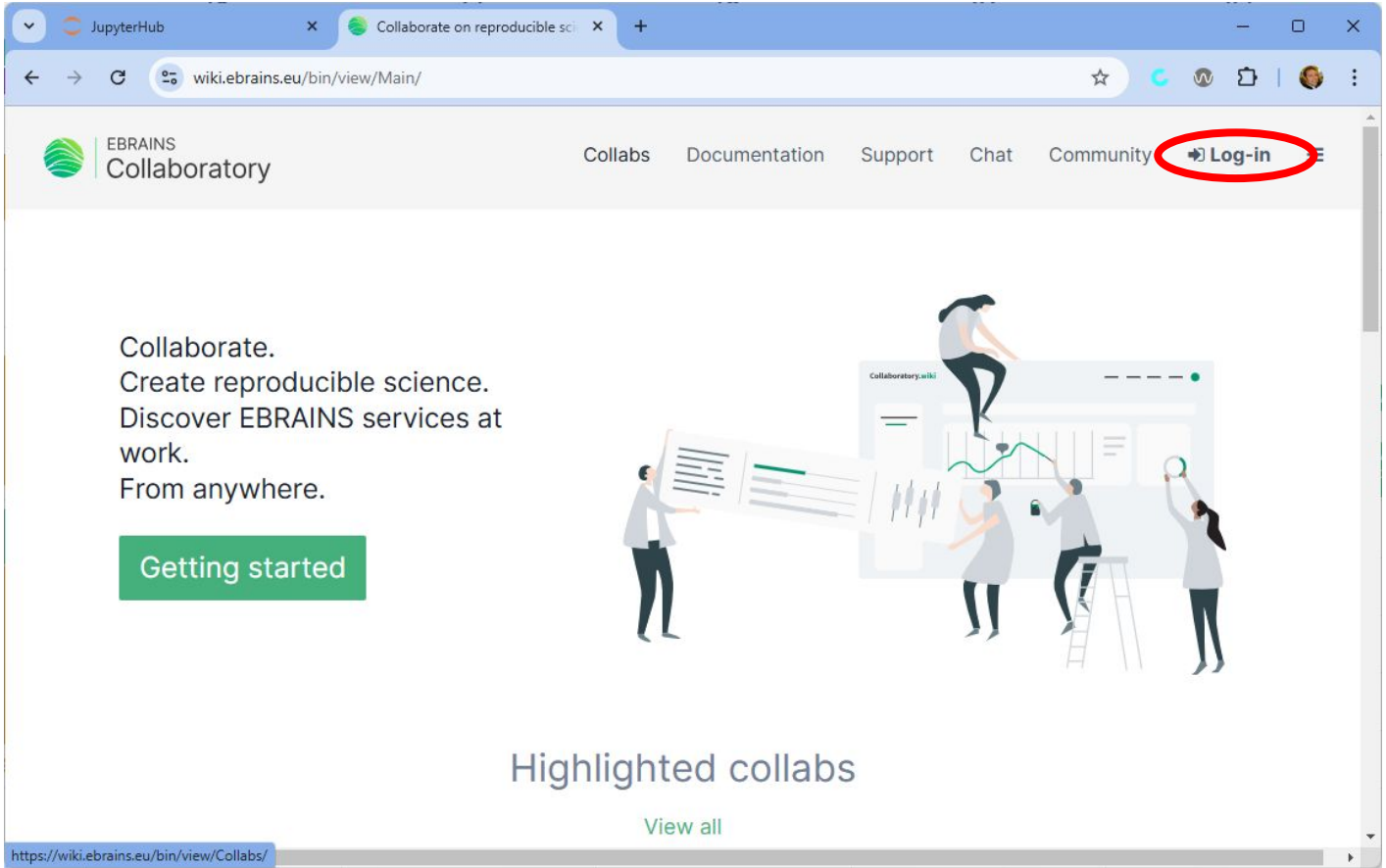
Accessing SpiNNaker

MANCHESTER 1824

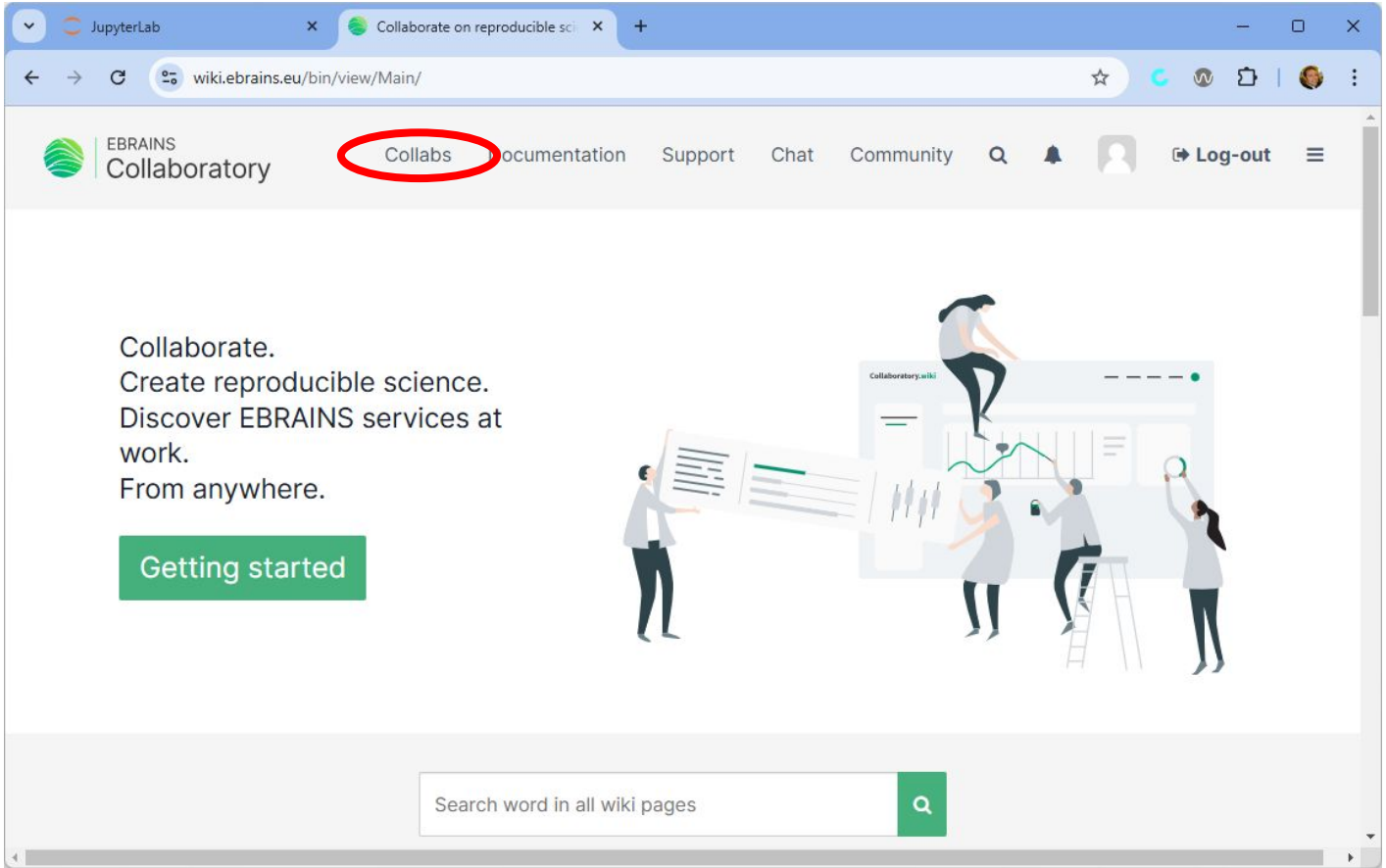
Accessing SpiNNaker via Jupyter - Create a Collaboratory

https://wiki.ebrains.eu/

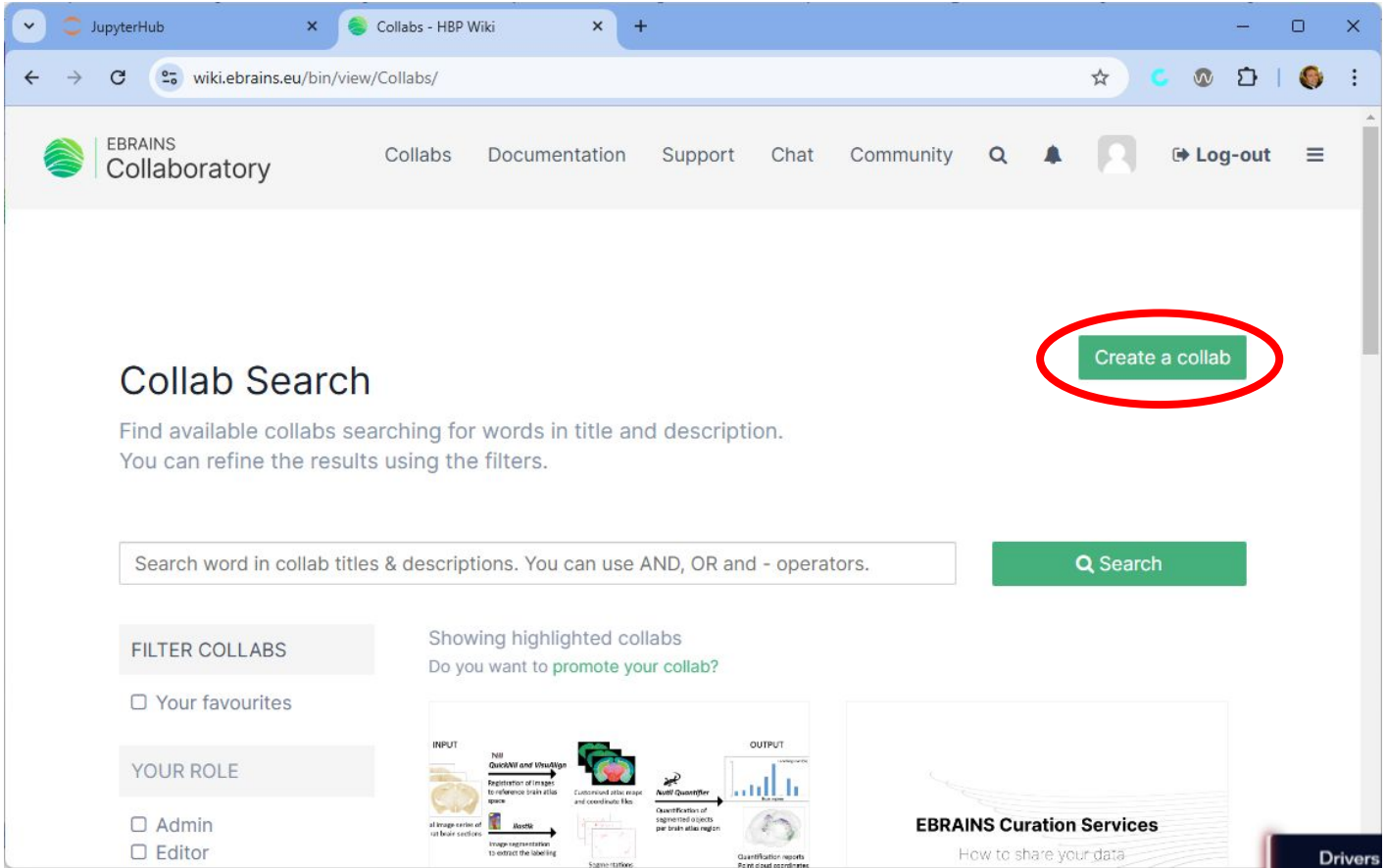
Log in to Wiki



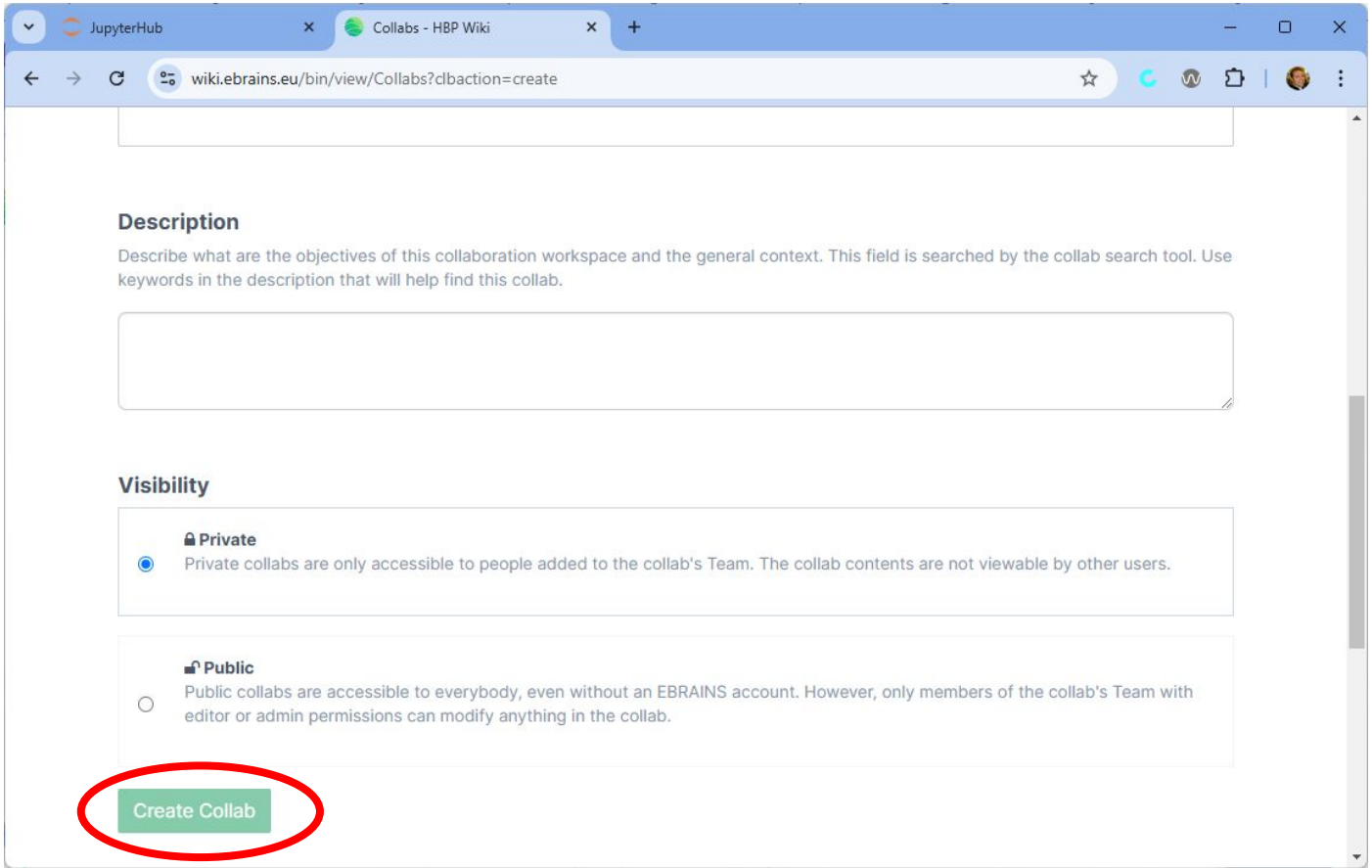
Create a Collaboratory



Create a Collaboratory



Create a Collaboratory

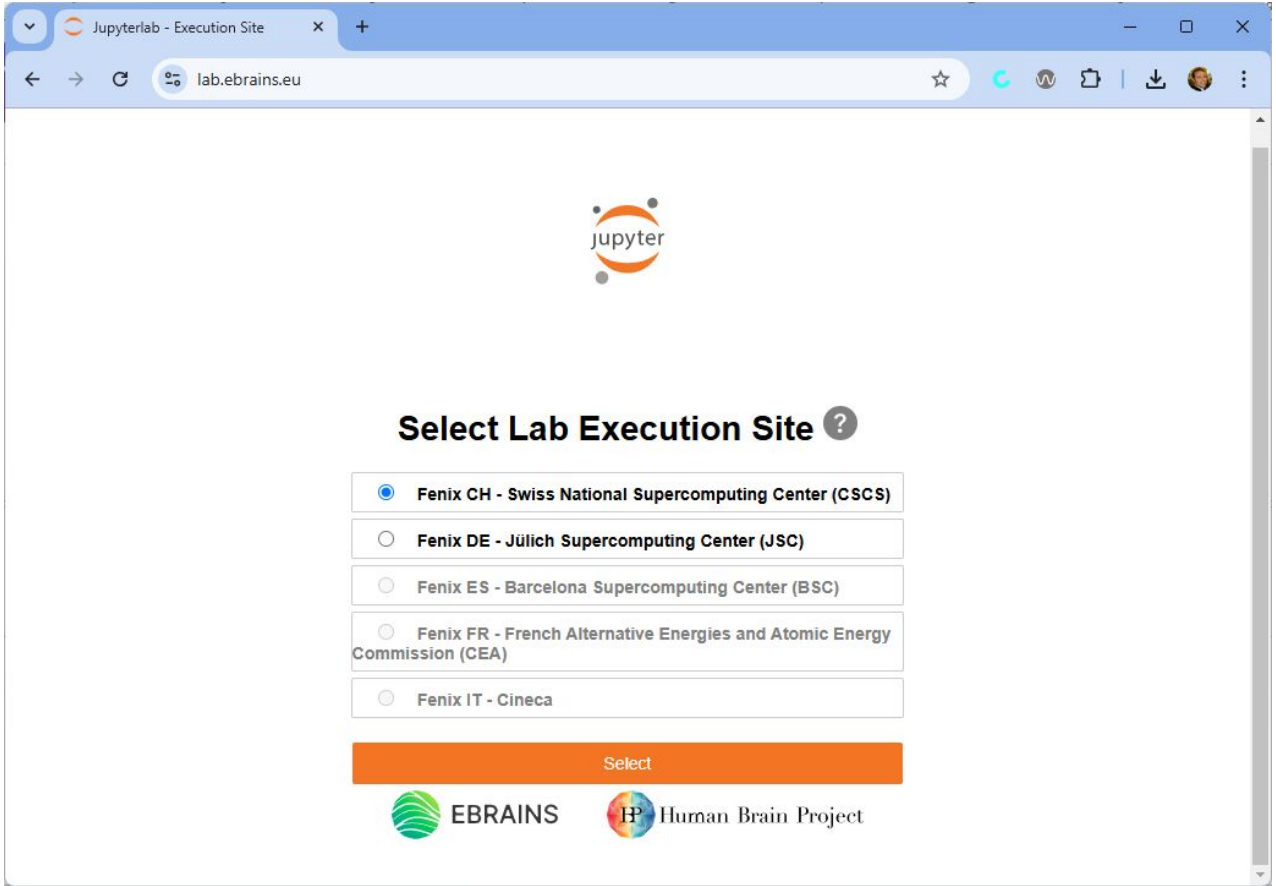


MANCHESTER 1824

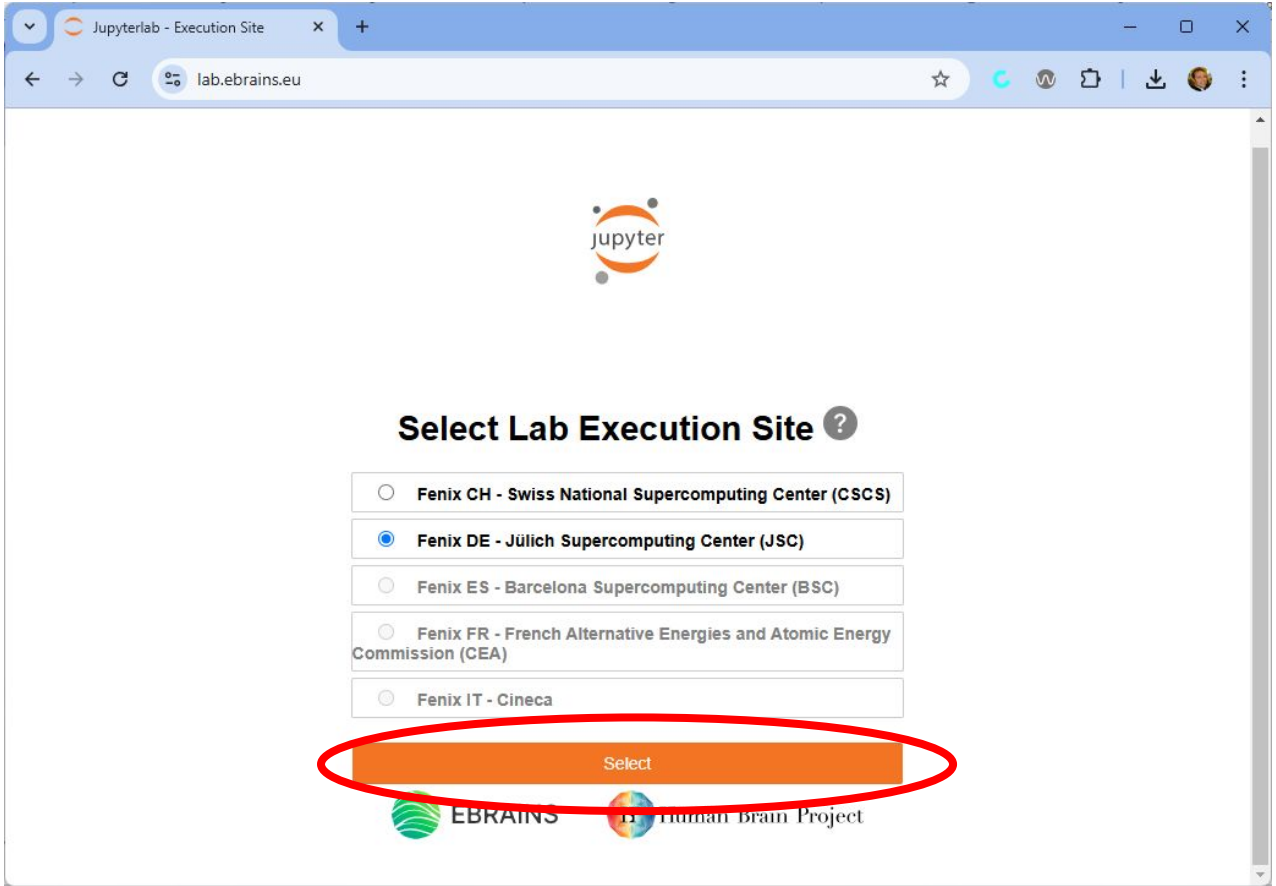
Accessing SpiNNaker via Jupyter - Go to EBRAINS Lab

https://lab.ebrains.eu/

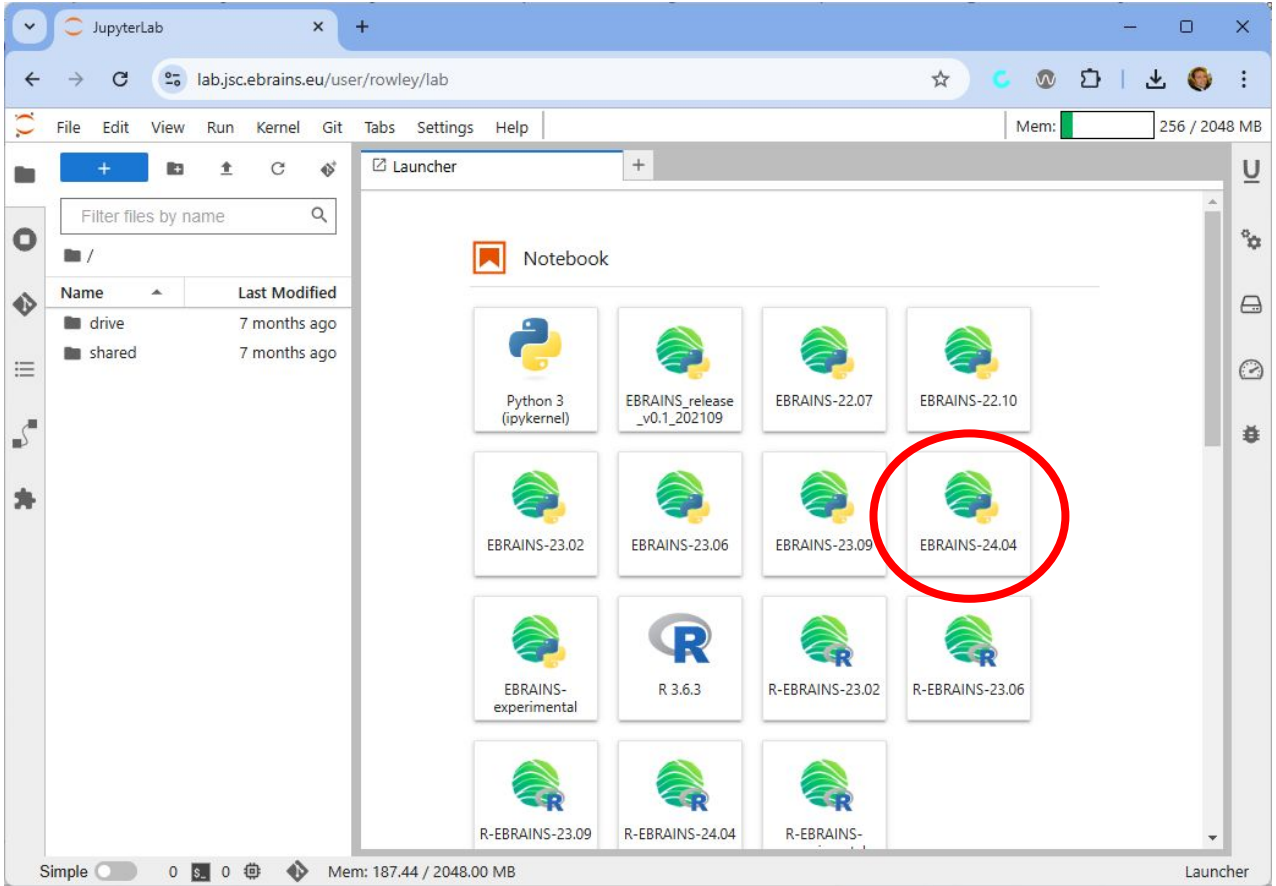
EBRAINS Lab - Choose a Site



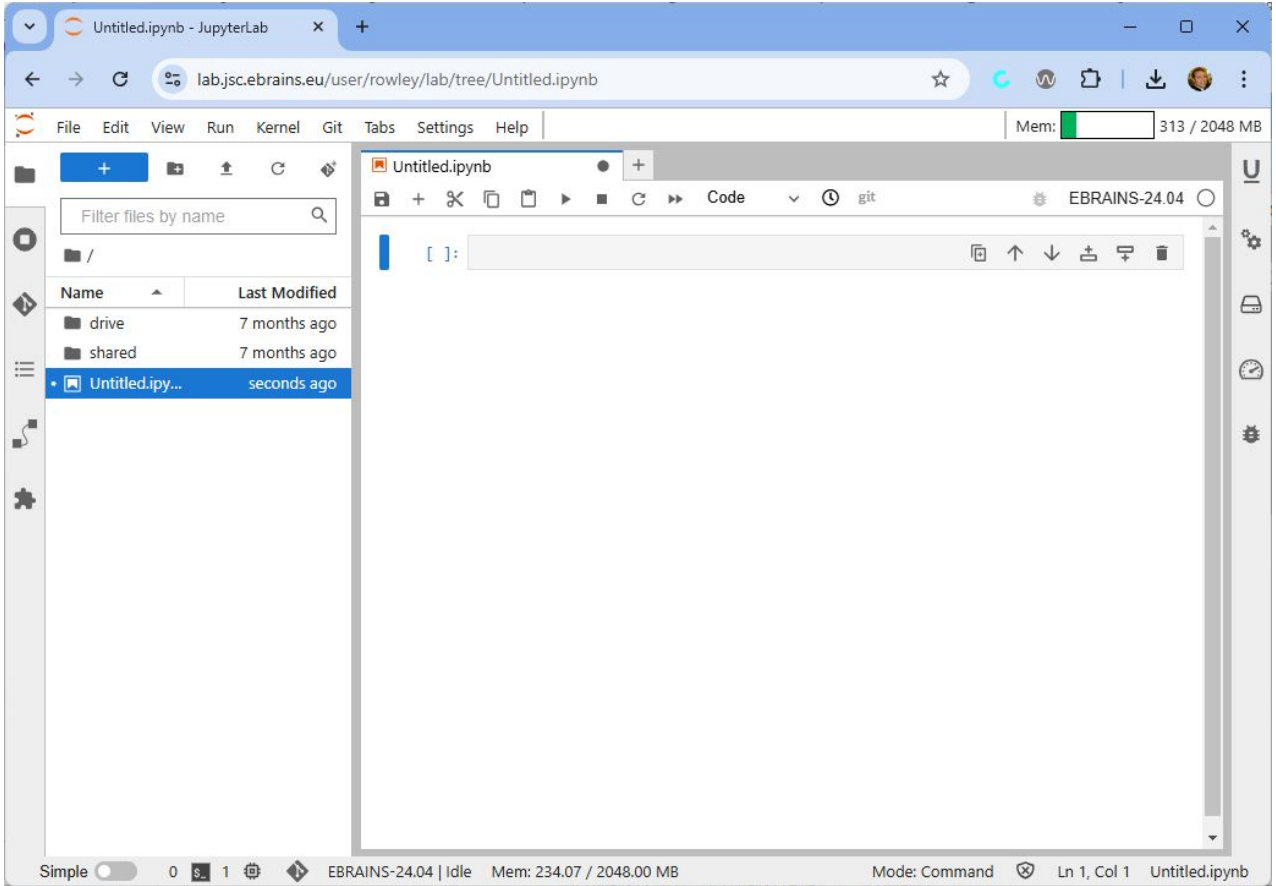
EBRAINS Lab - Choose a Site



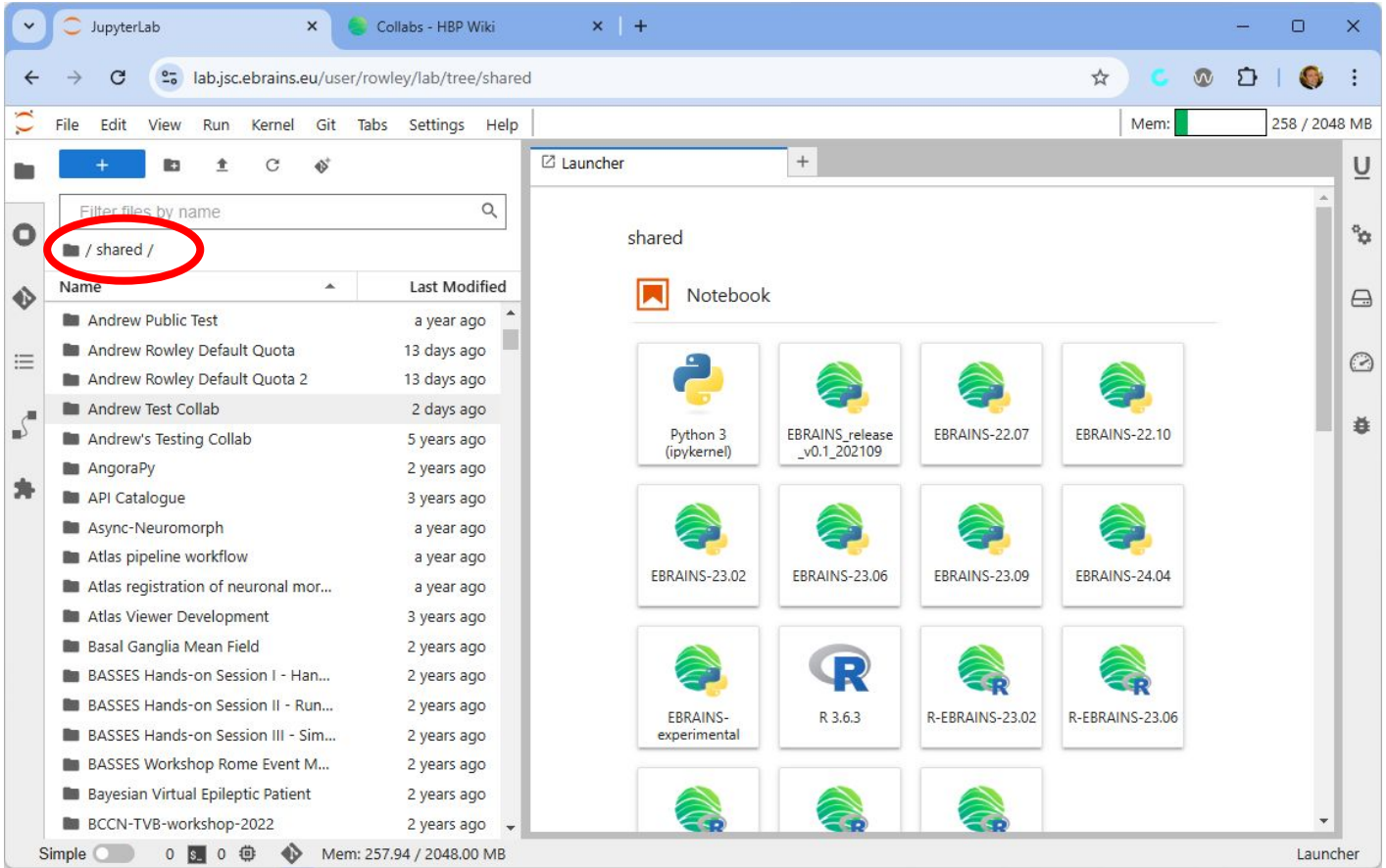
EBRAINS Lab - Choose a Kernel



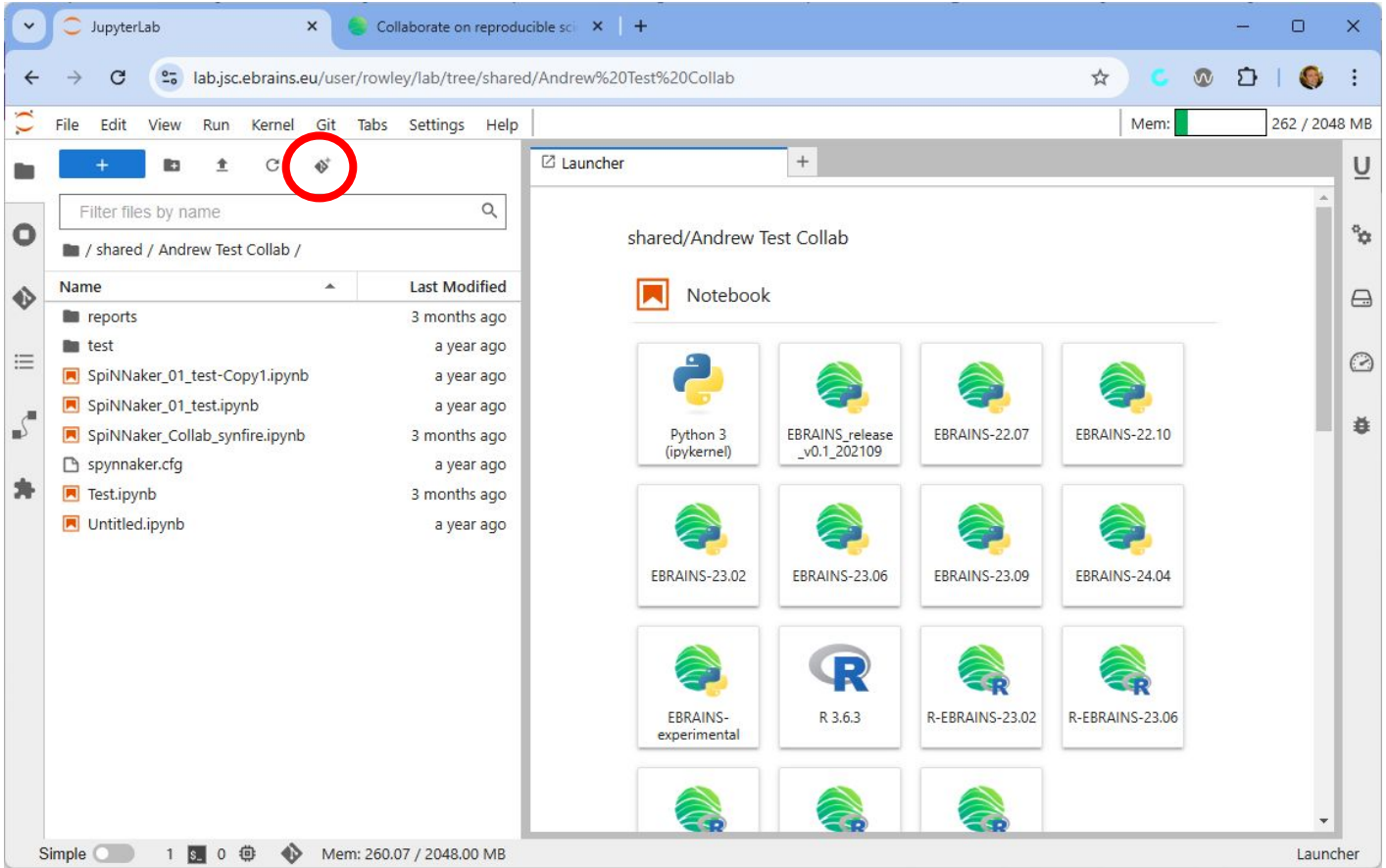
EBRAINS Lab - Choose a Kernel



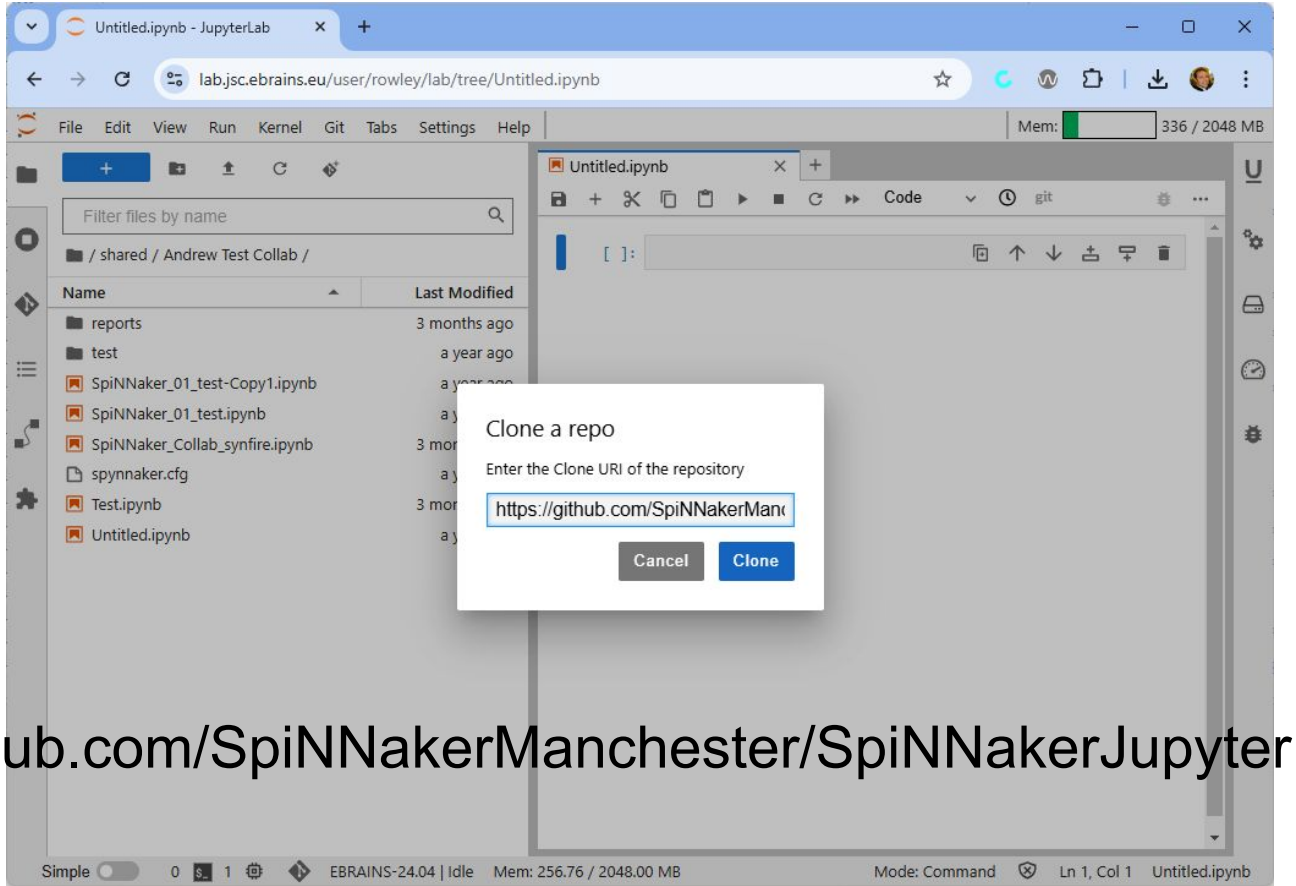
Find your Collab: /shared/…



Clone SpiNNaker Repository

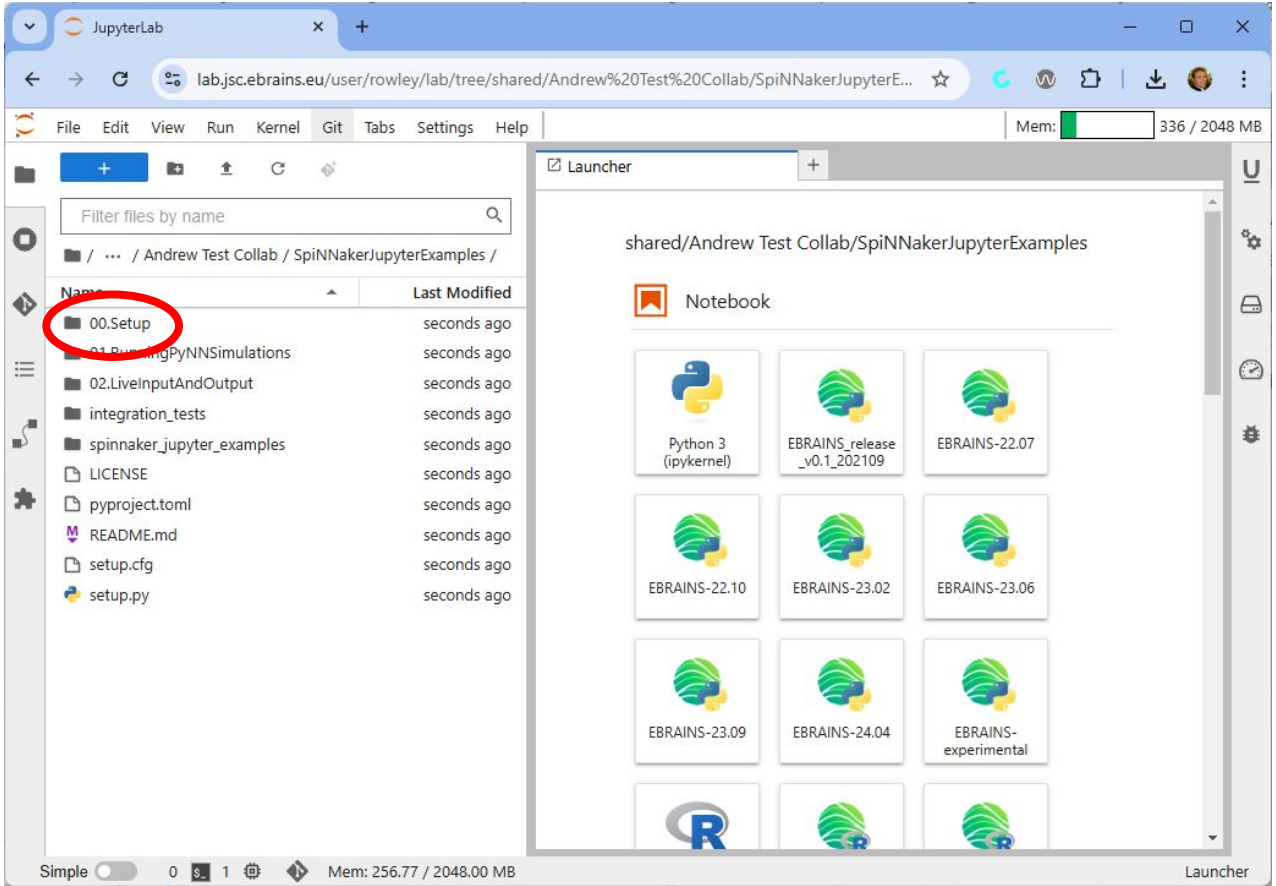


Clone SpiNNaker Repository

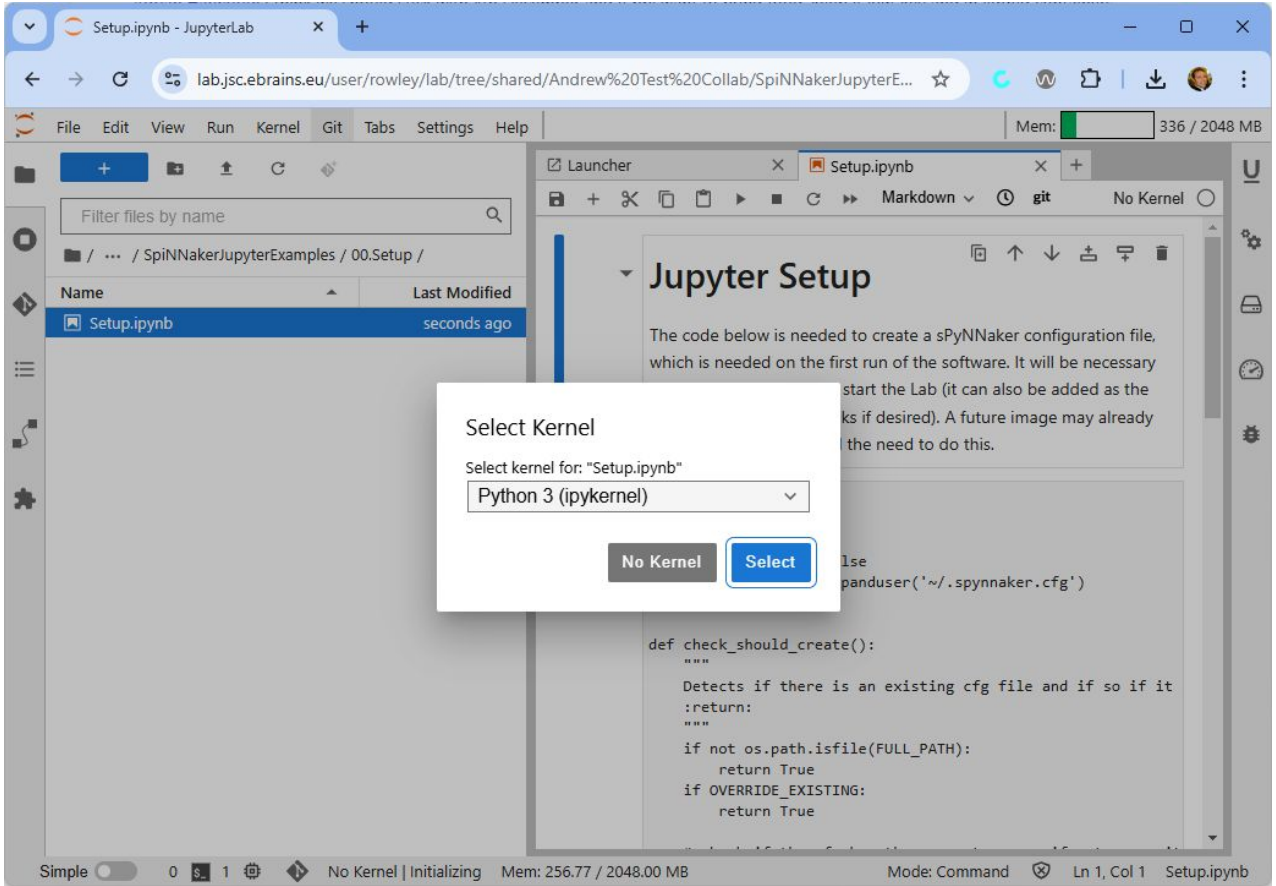


https://github.com/SpiNNakerManchester/SpiNNakerJupyterExamples

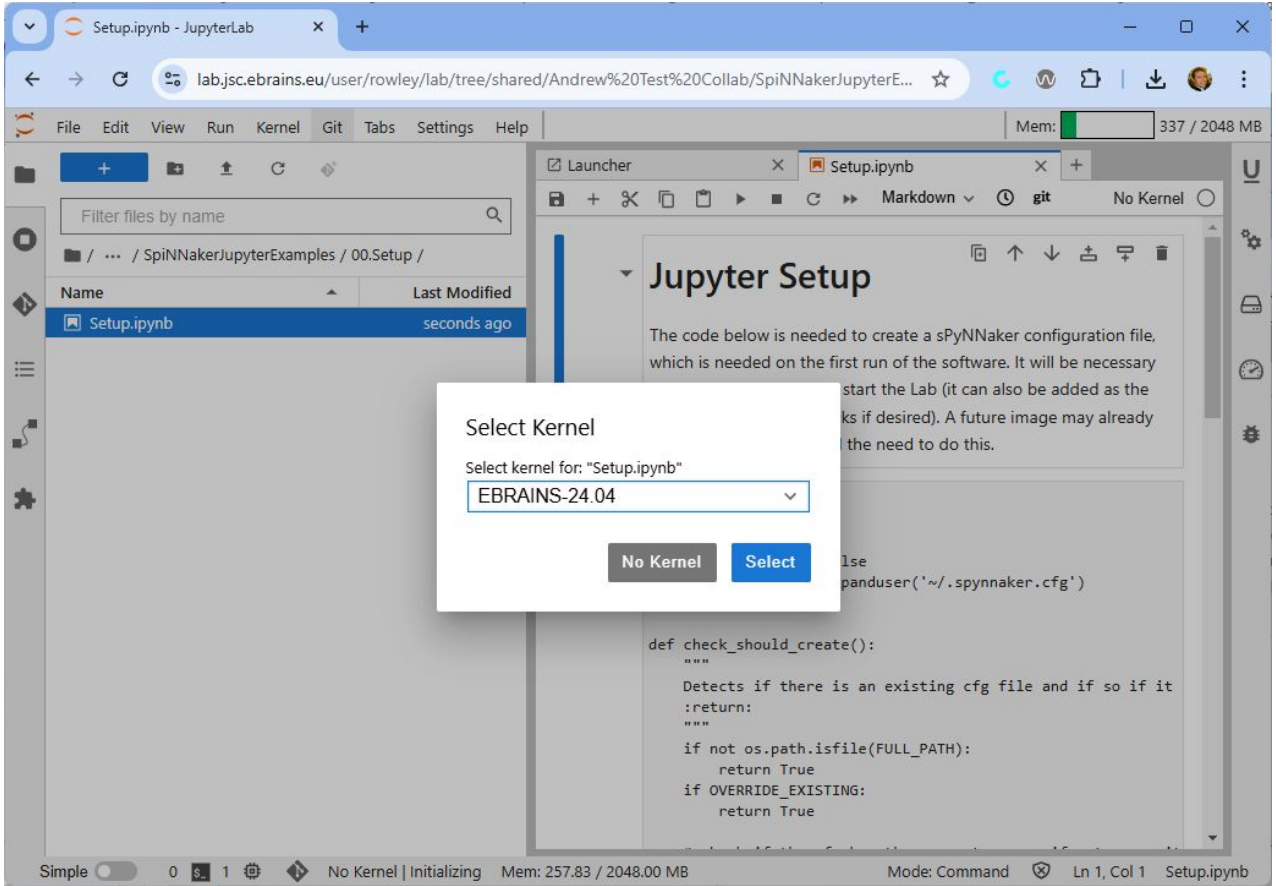
Clone SpiNNaker Repository



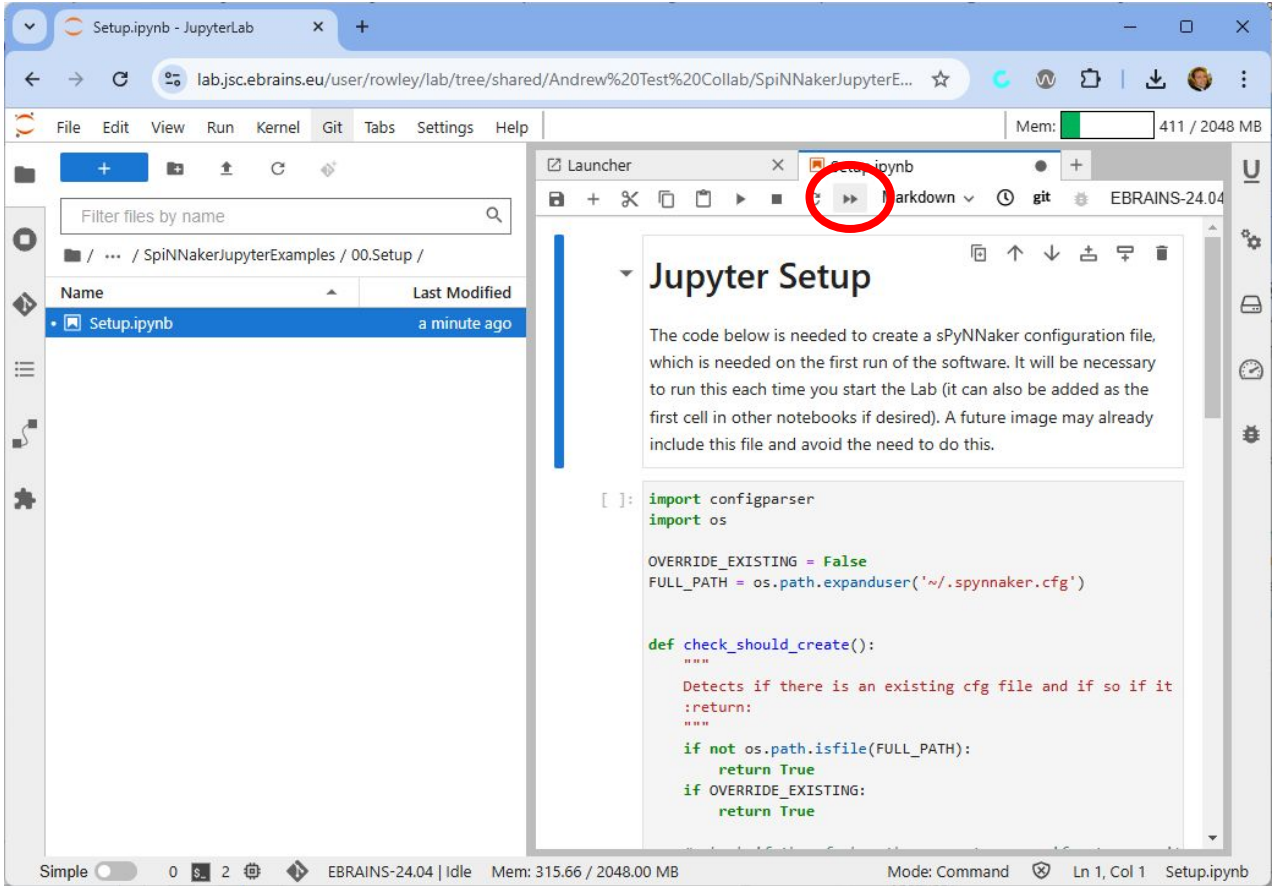
Open Setup Notebook



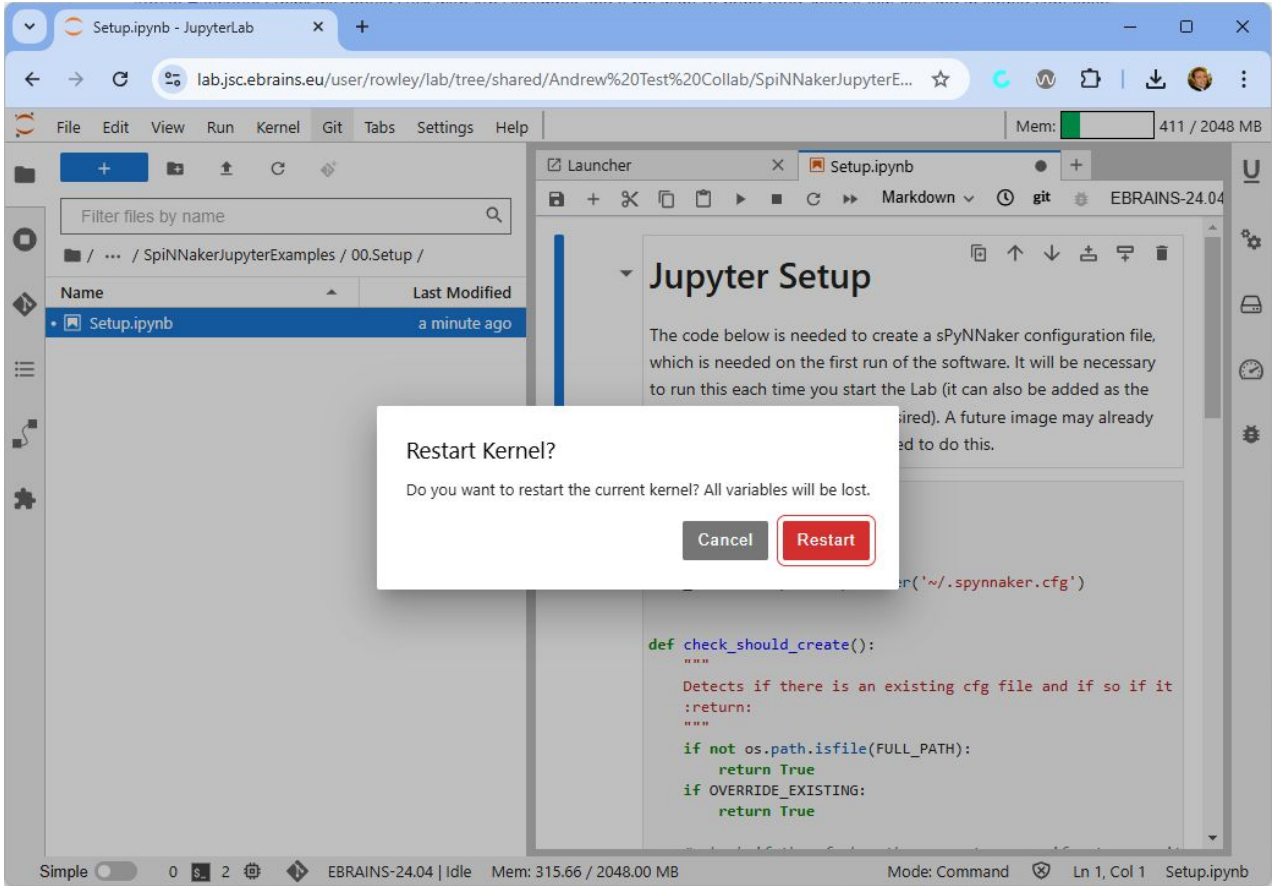
Open Setup Notebook



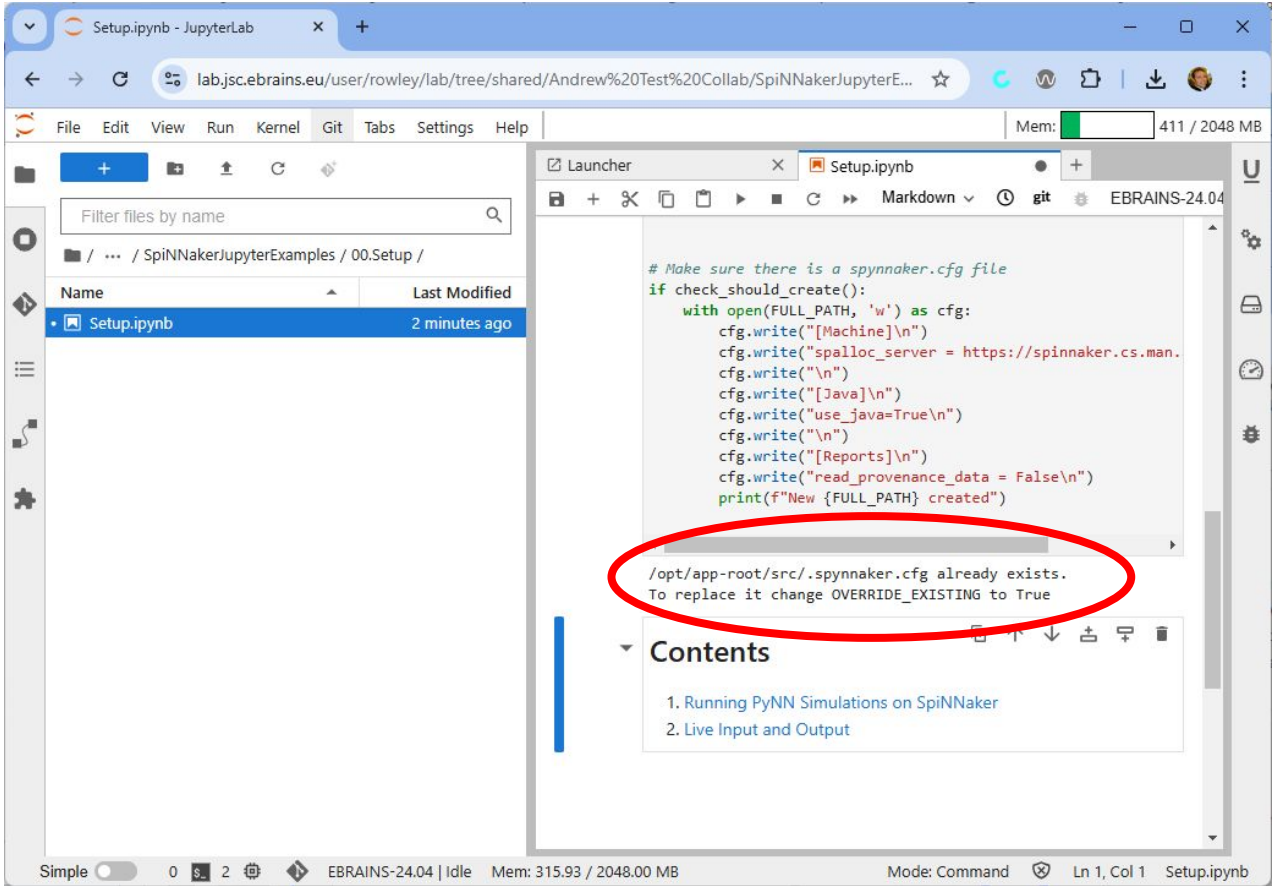
Open Setup Notebook - Run



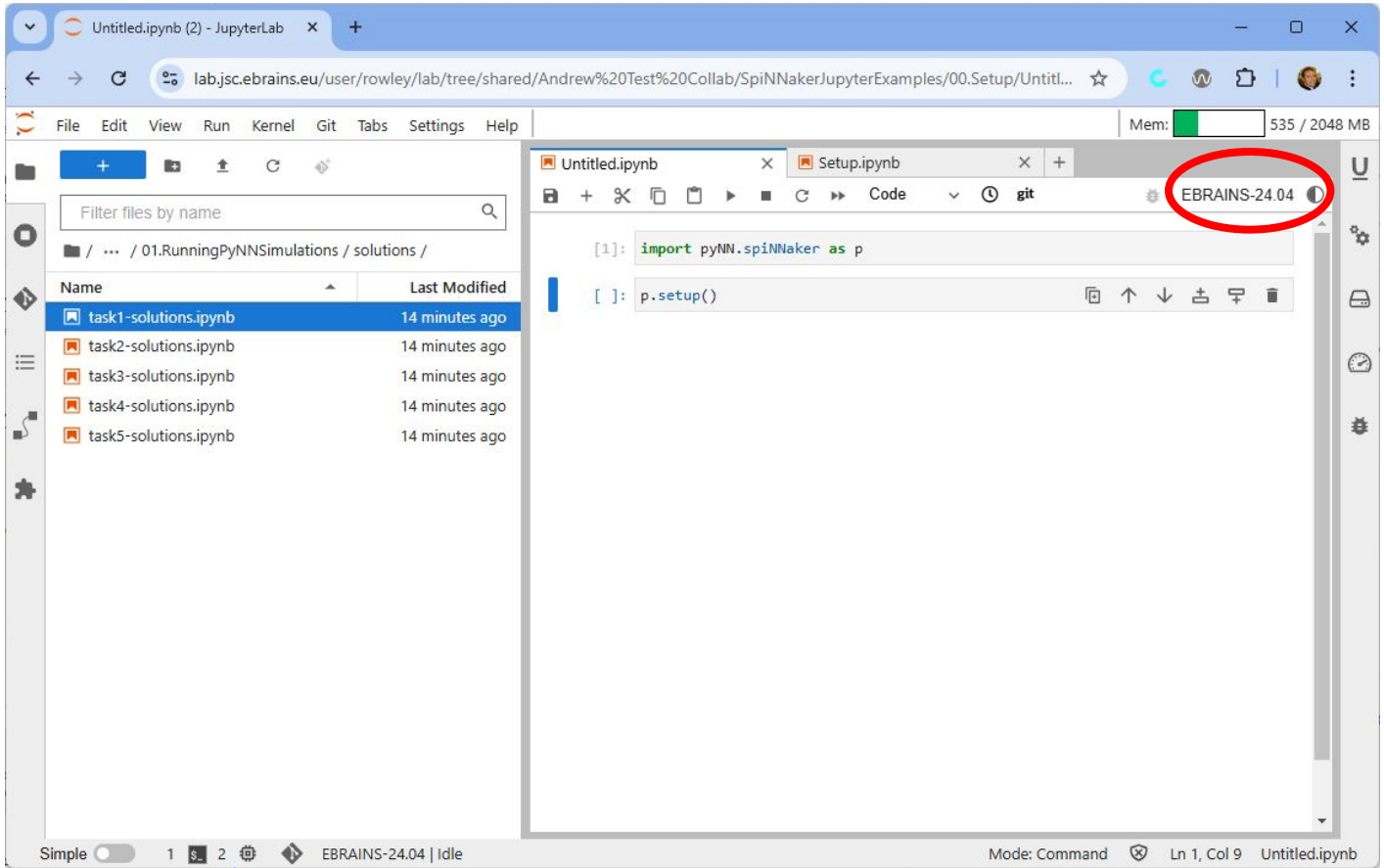
Open Setup Notebook - Run



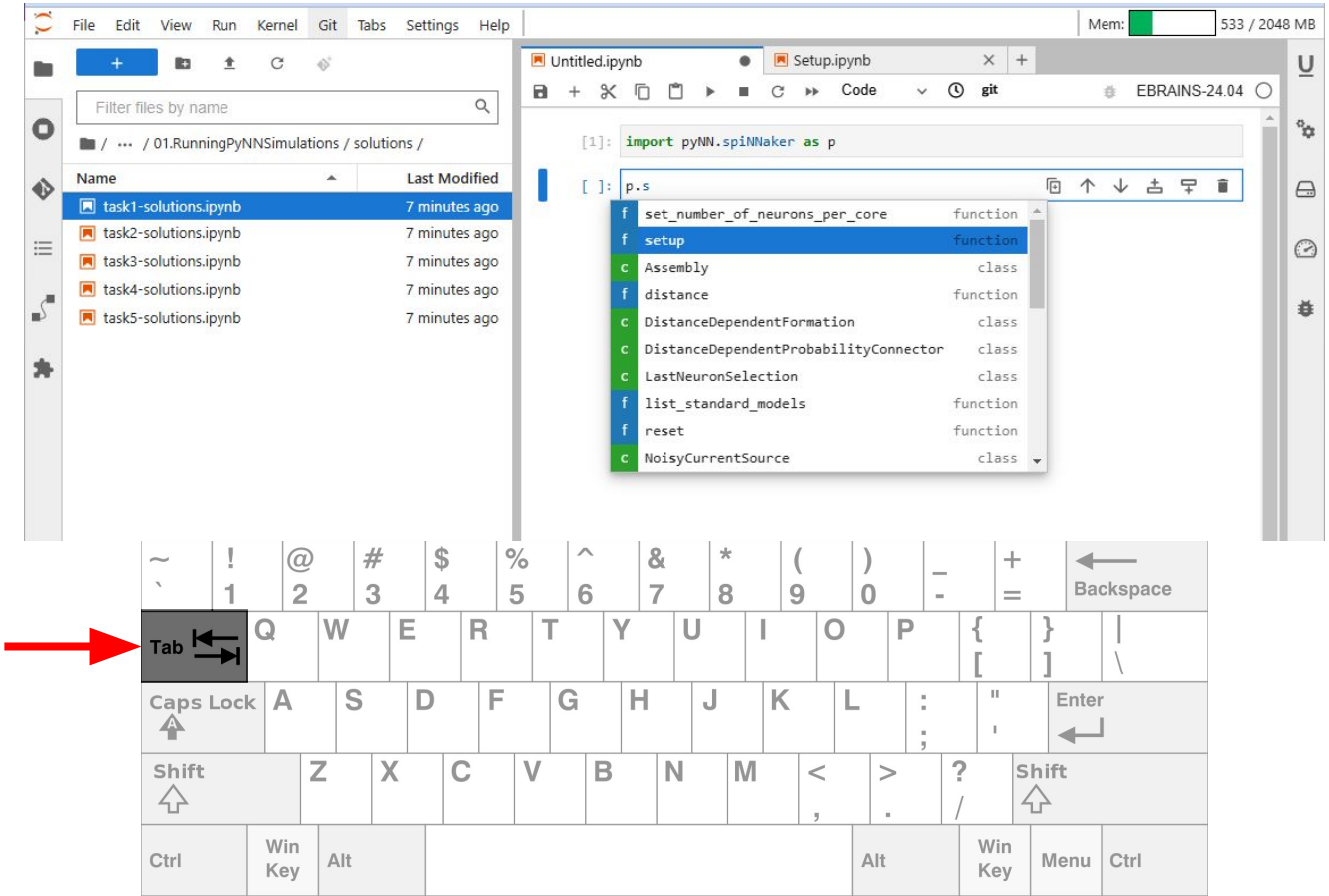
Open Setup Notebook - Run



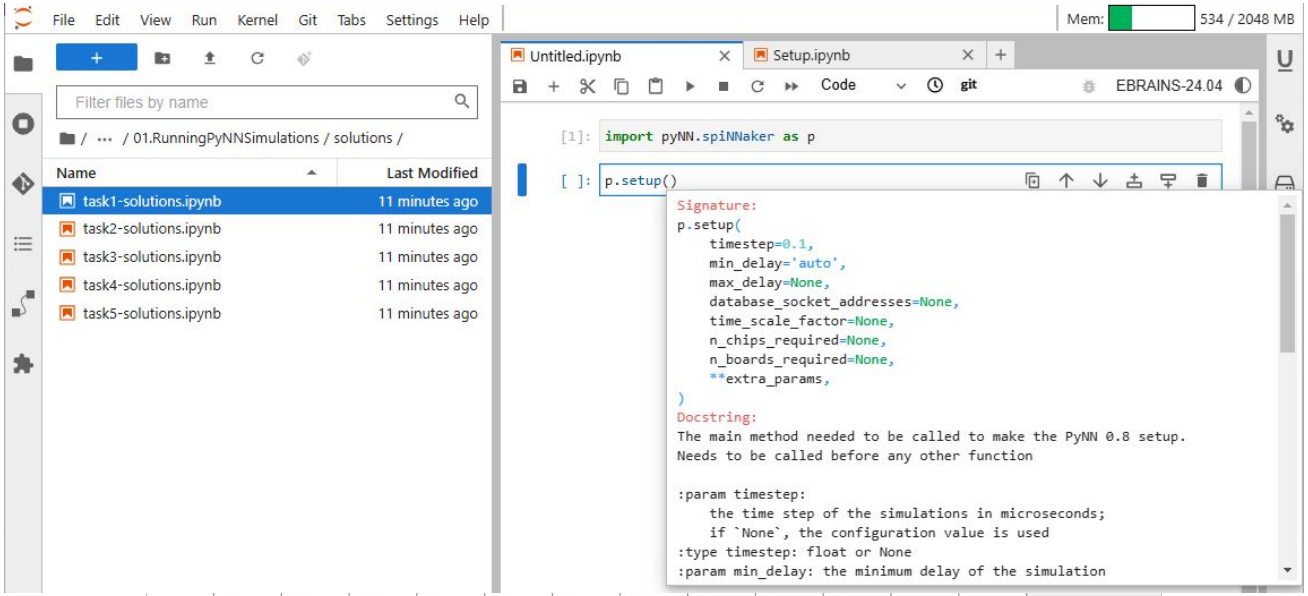
Changing Kernel



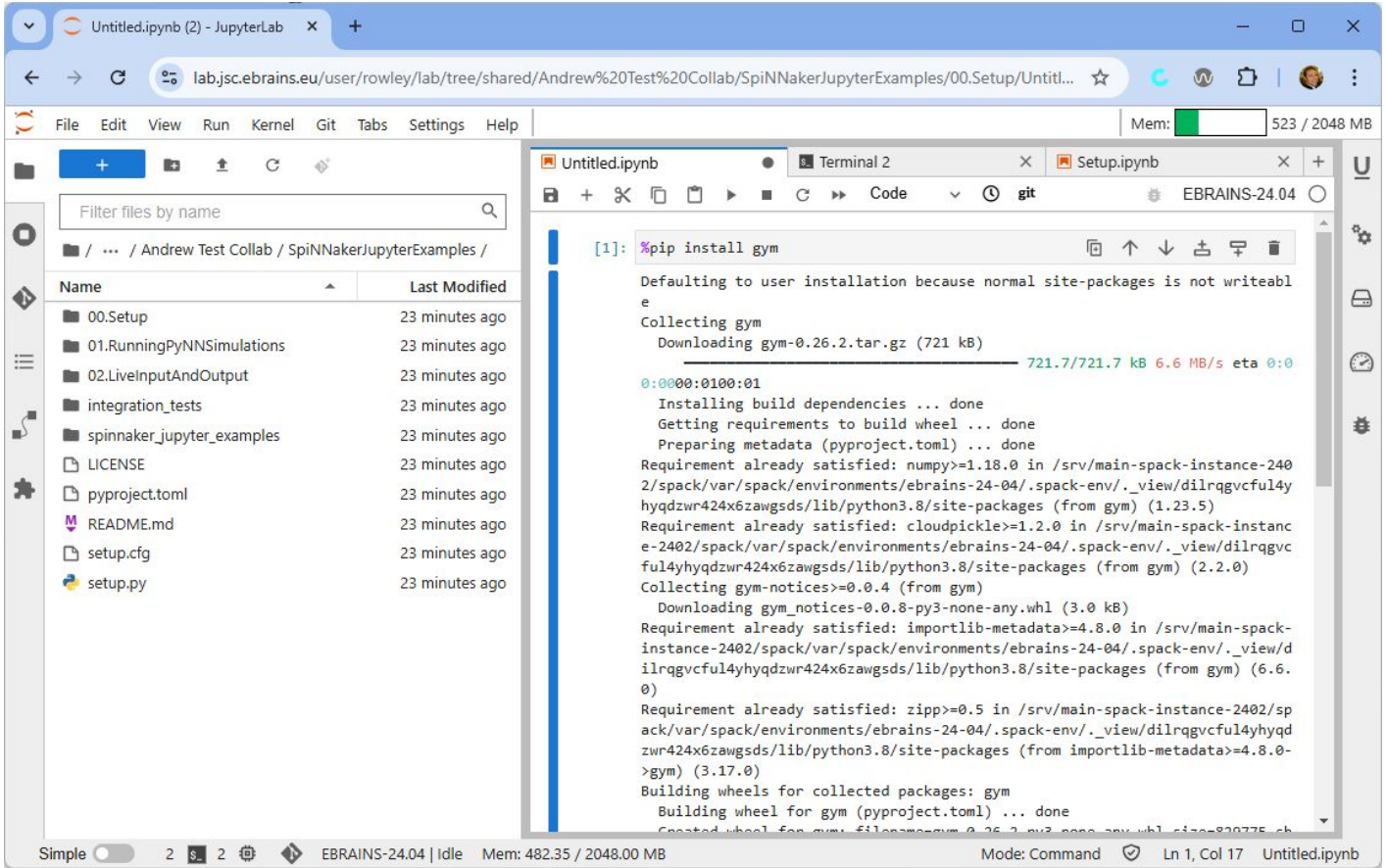
Jupyter Autocomplete



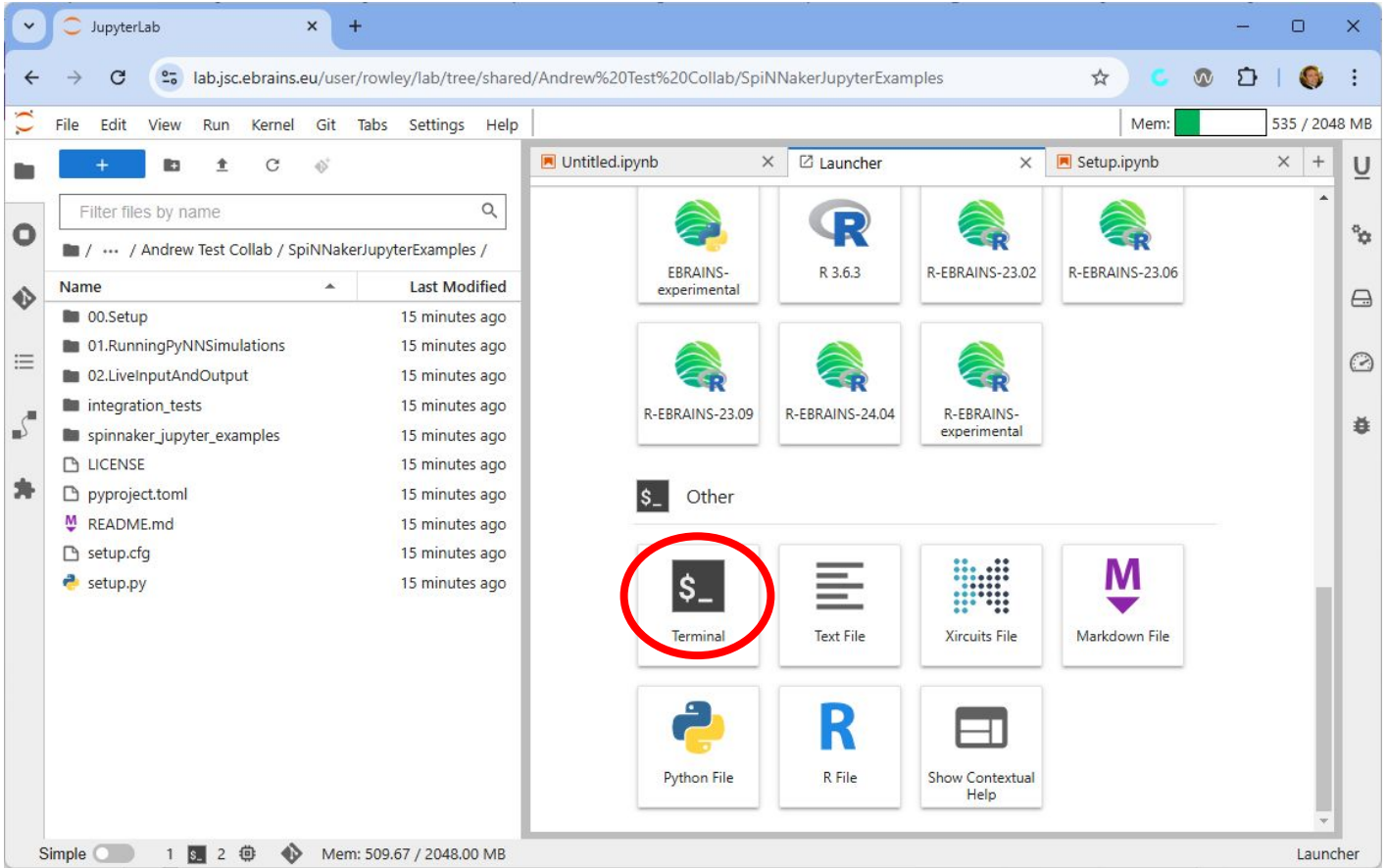
Jupyter Function Help



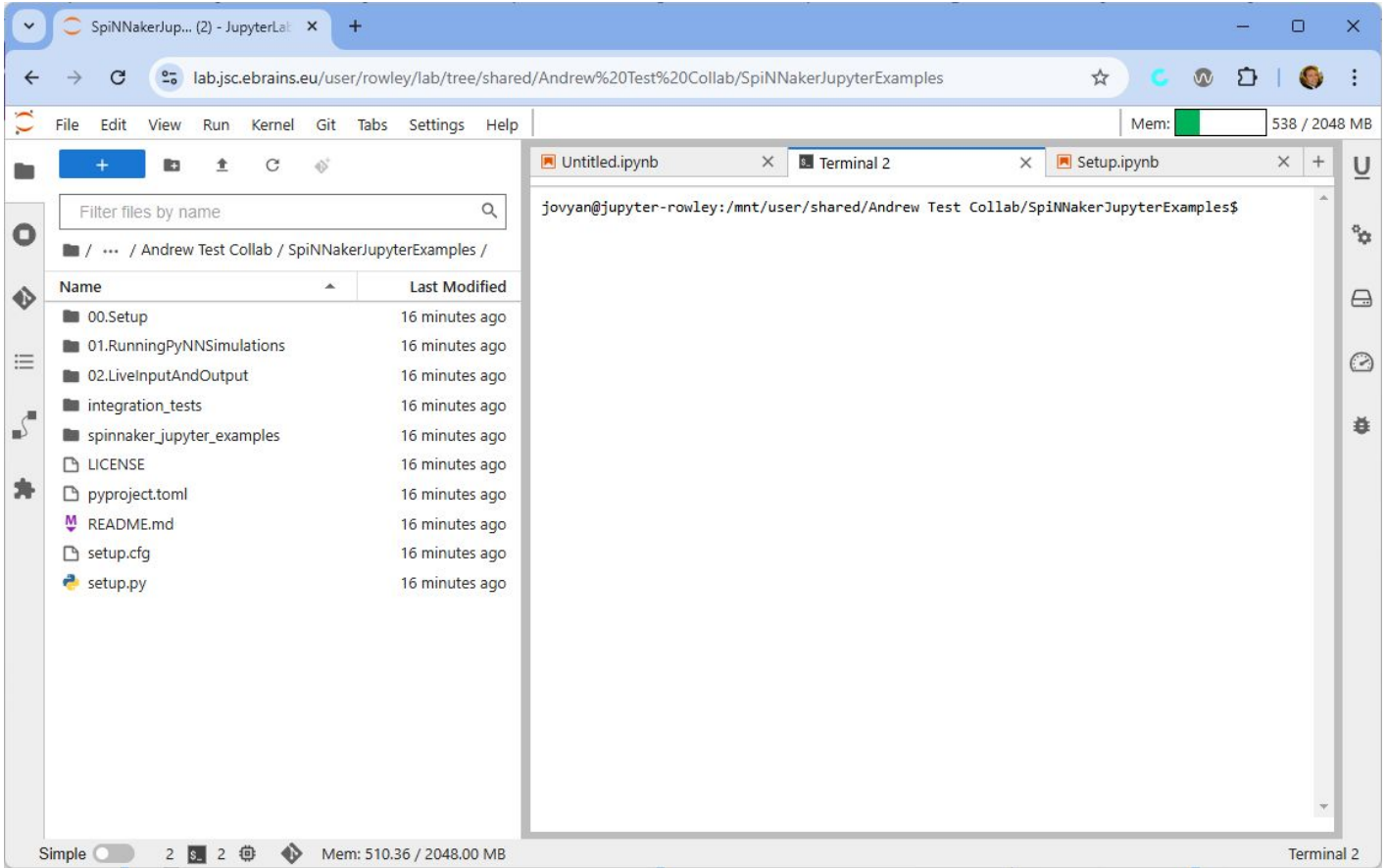
Install Libraries



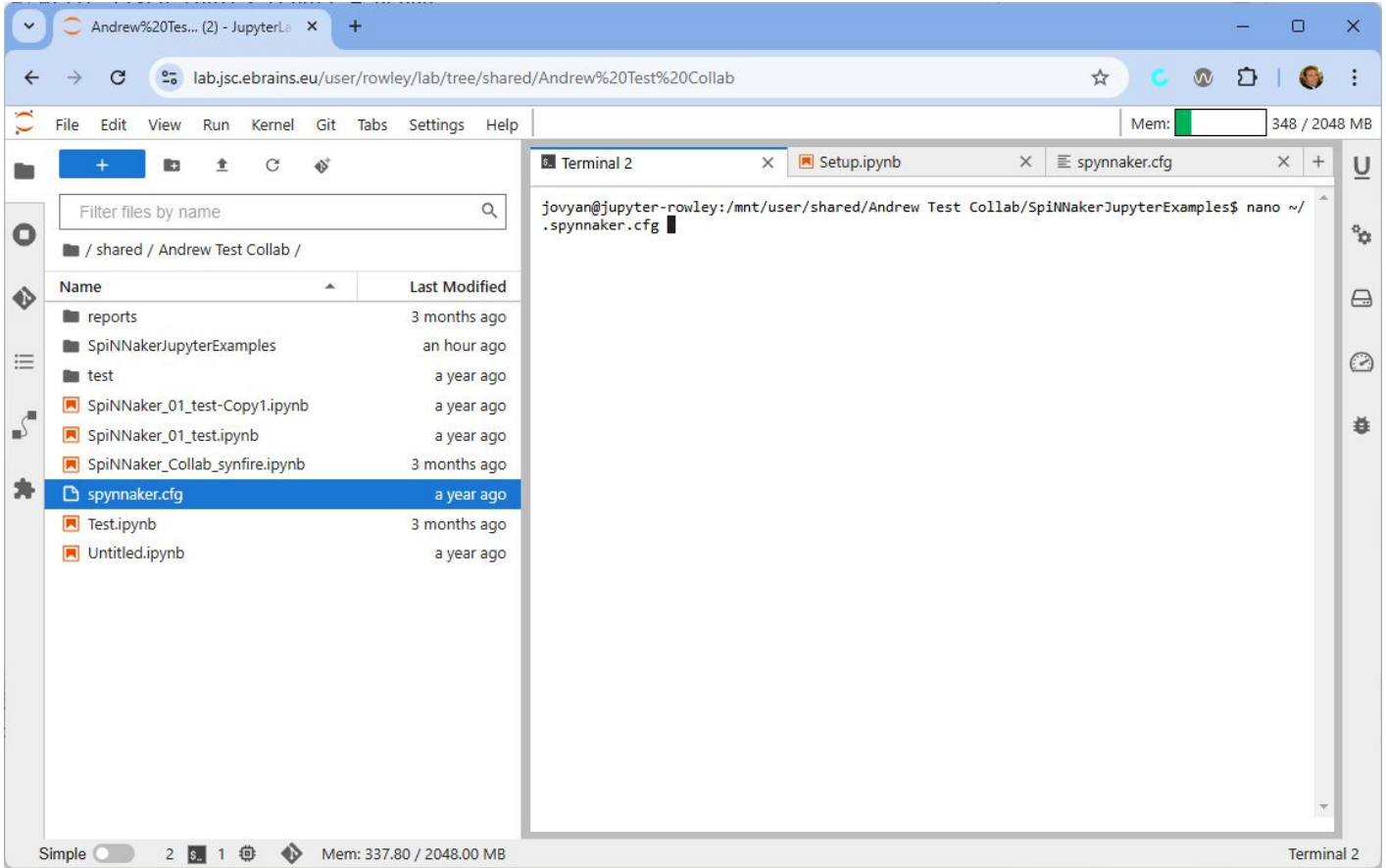
Terminal Access



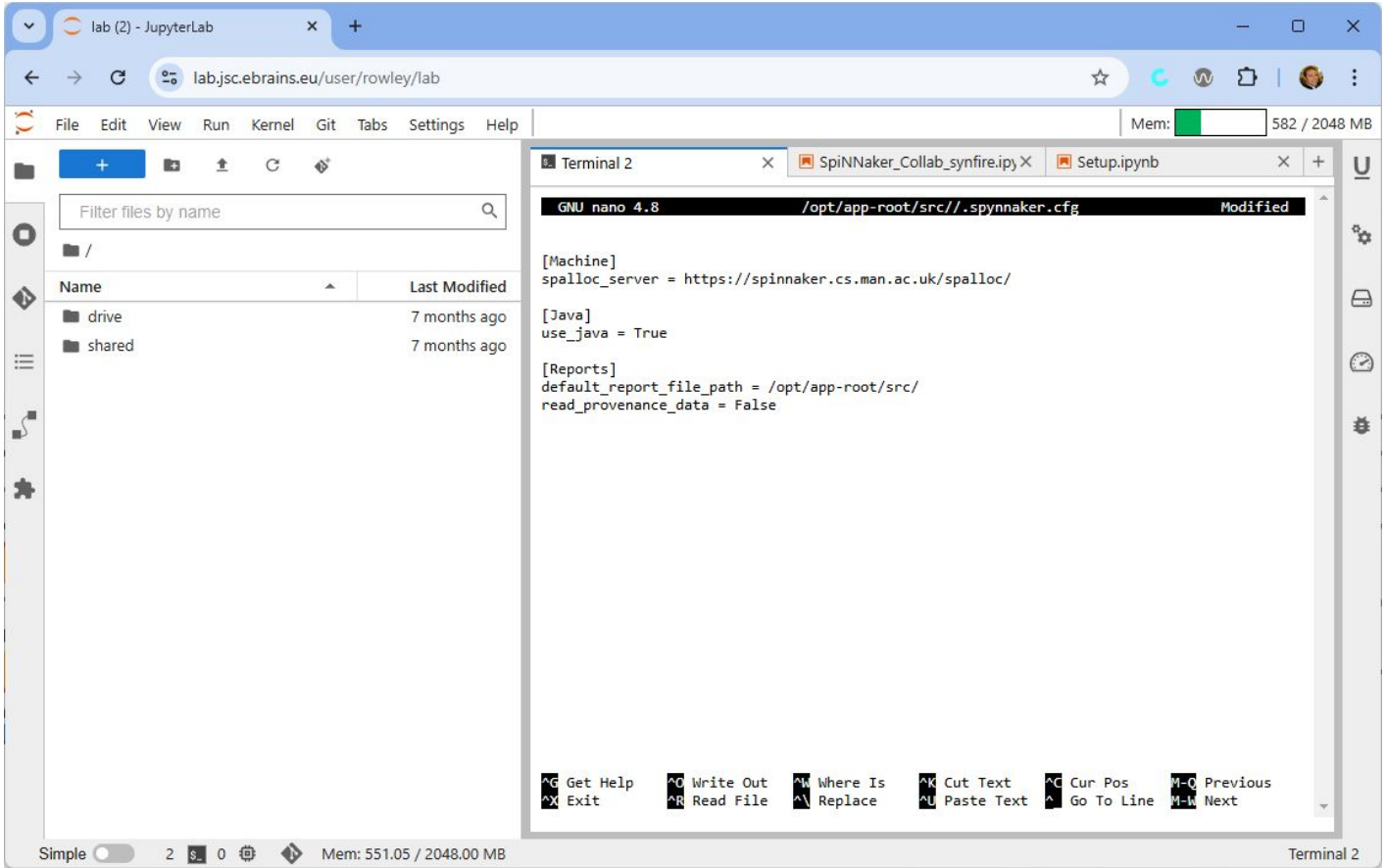
Terminal Access



Edit SpiNNaker Configuration



Set Reports Options

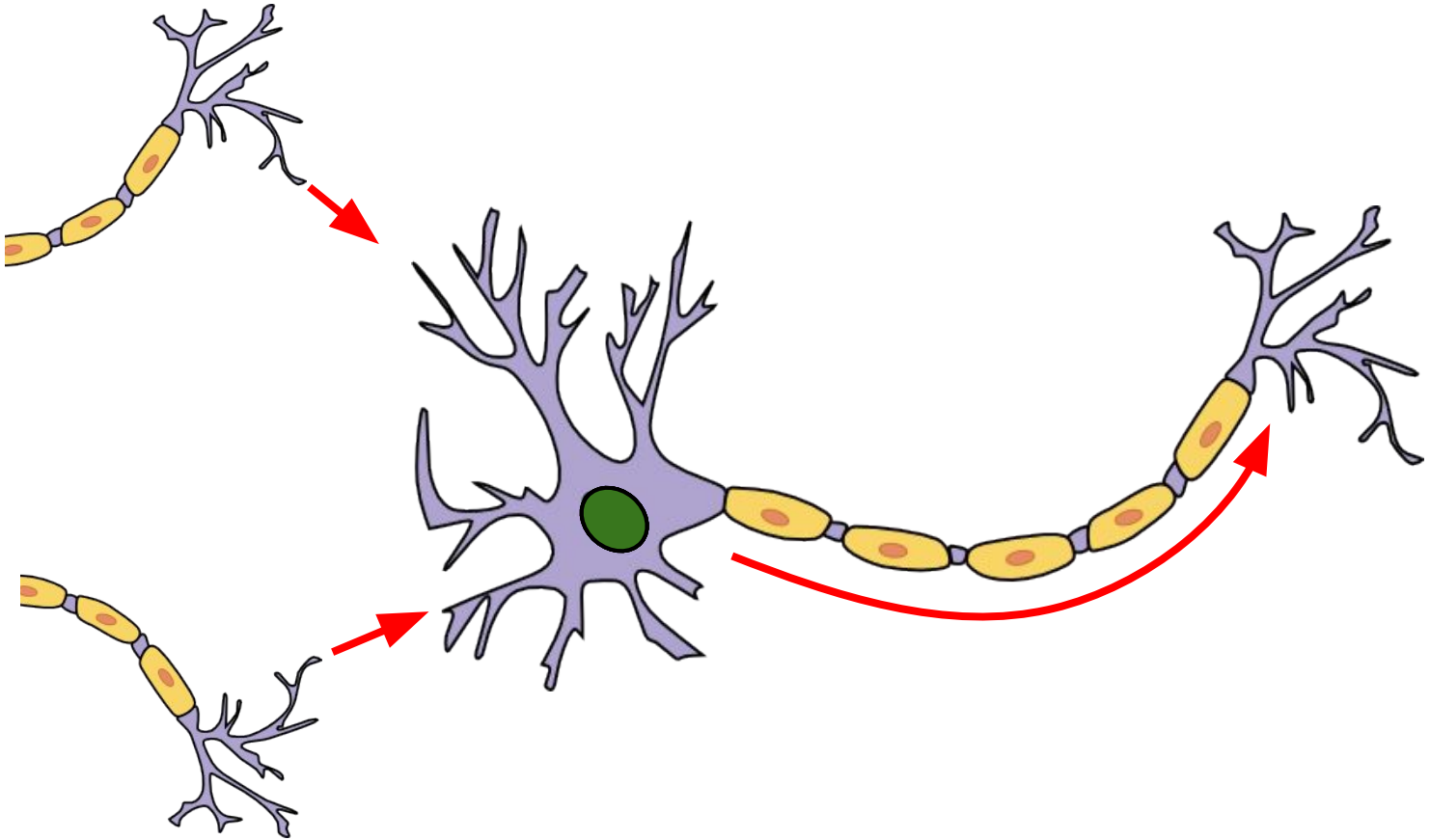


MANCHESTER 1824

Spiking Neural Networks

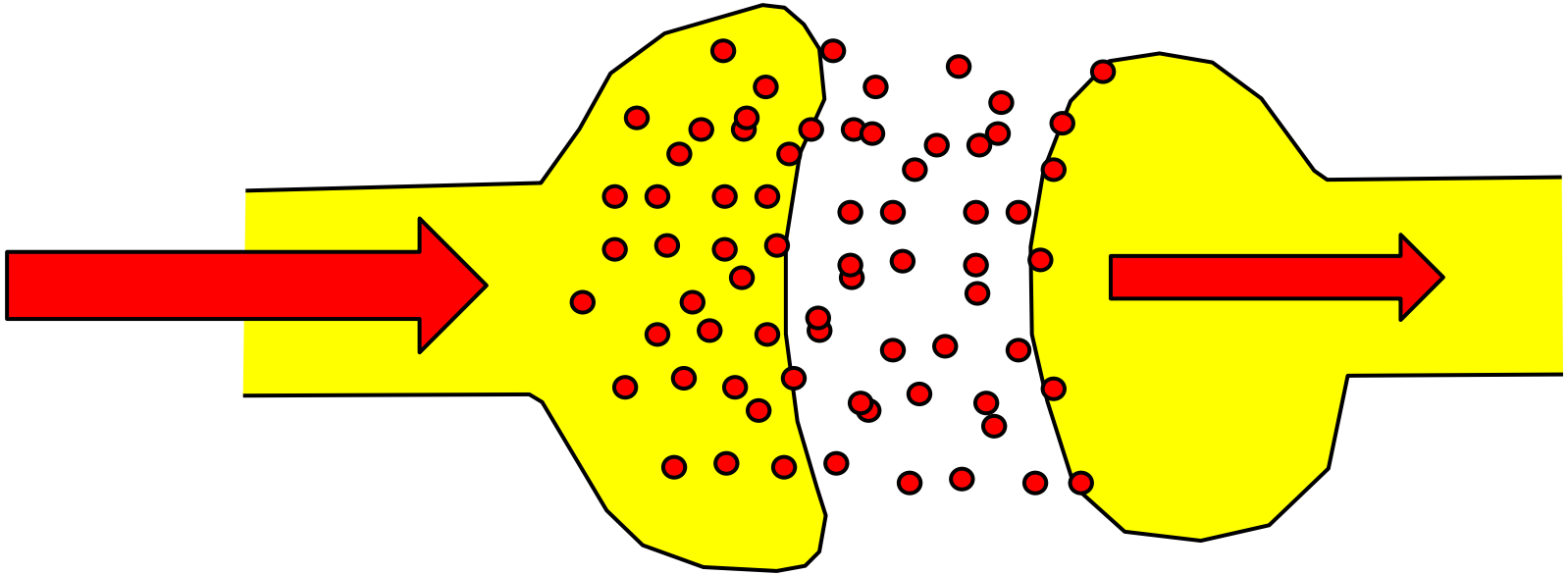
MANCHESTER 1824

Spiking Neural Networks



MANCHESTER 1824

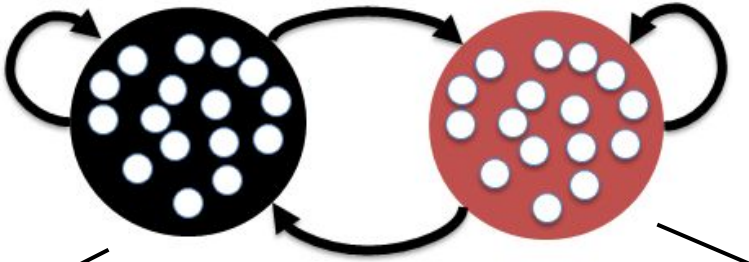
Spiking Neural Networks



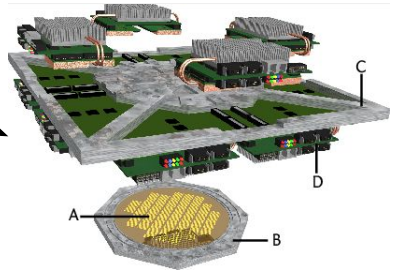
MANCHESTER
1824

PyNN

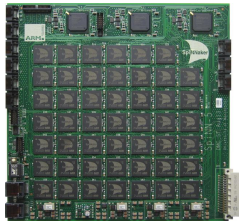
What is PyNN?

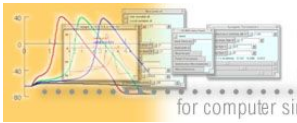


nest :: initiative



BRIAN





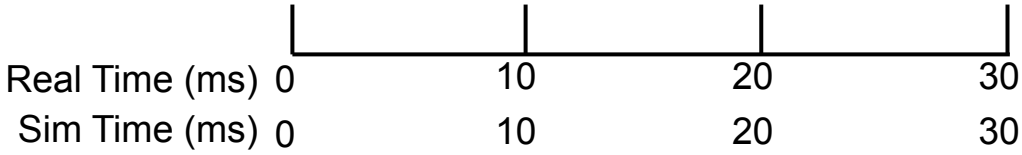
NEURON

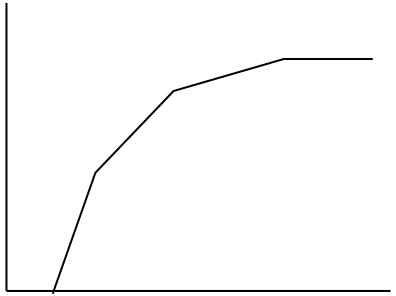
for computer simulations of neurons and neural networks

PyNN - Setup

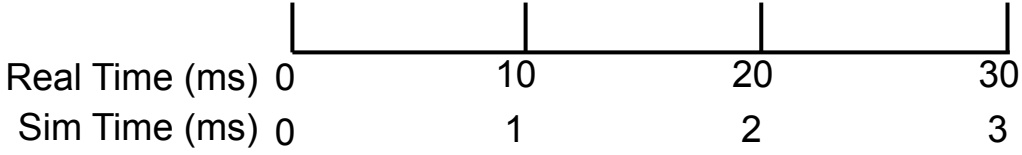
```
import pyNN.spiNNaker as p
```

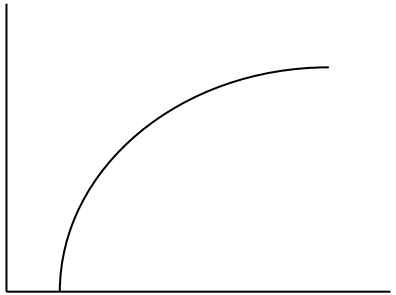
```
p.setup(timestep=1.0)
```





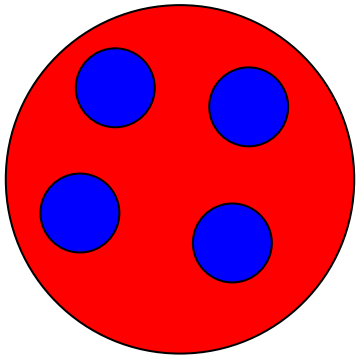
```
p.setup(timestep=0.1)
```

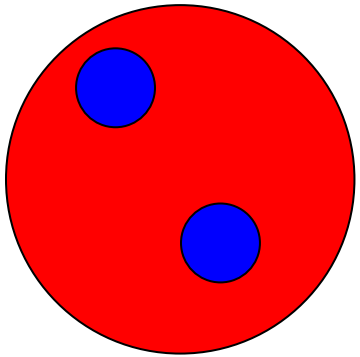




PyNN - Populations

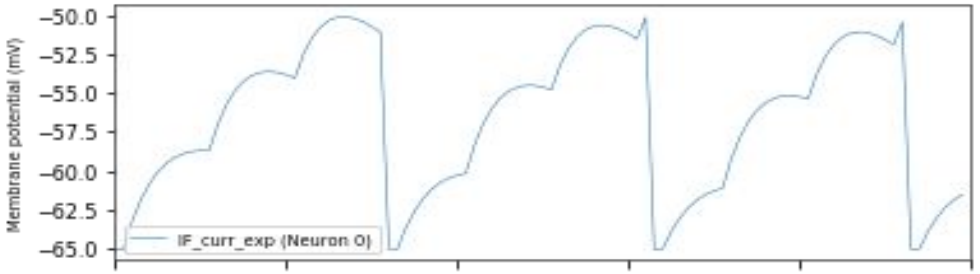
```
pop_1 = p.Population(
    4, p.IF_curr_exp(), label="Fred")
pop_2 = p.Population(
    2, p.IF_curr_exp(), label="Bob")
```



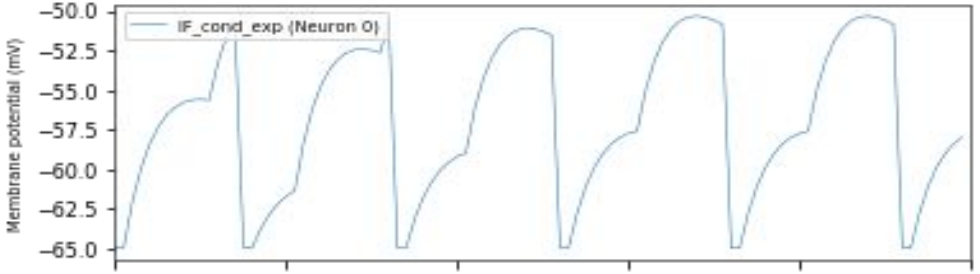


PyNN Populations - Models

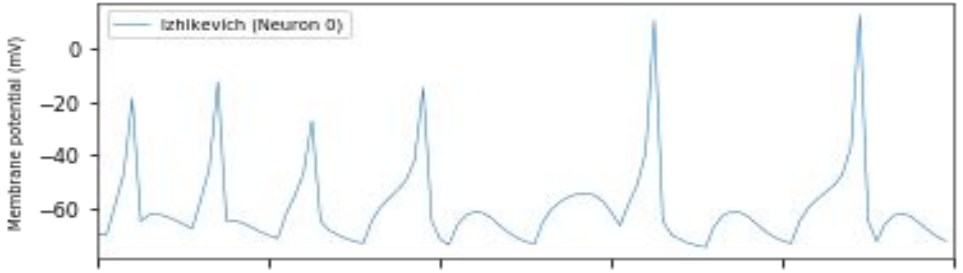
```
p.IF_curr_exp(...)
```




```
p.IF_cond_exp(...)
```

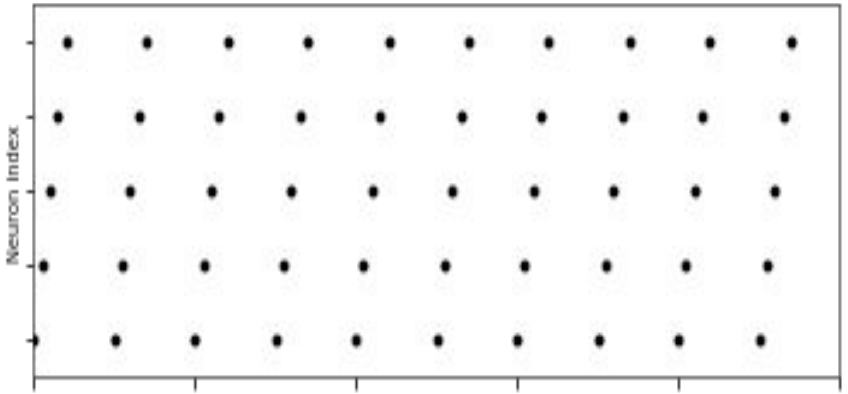



```
p.Izhikevich(...)
```

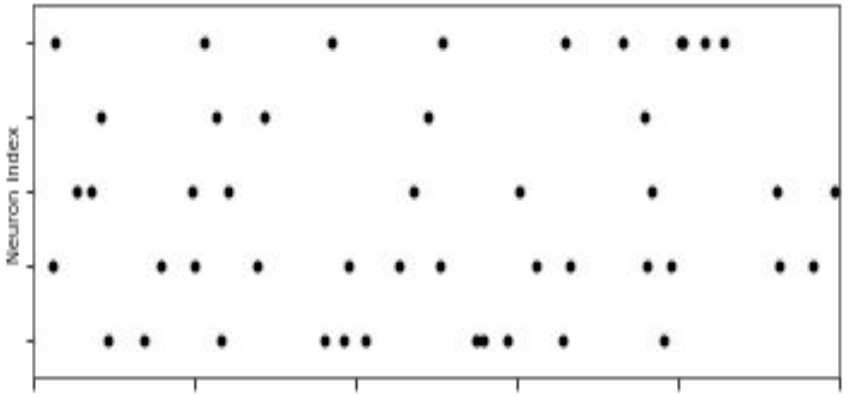


PyNN Populations - Models

```
p.SpikeSourceArray(
    spike_times=[...])
```

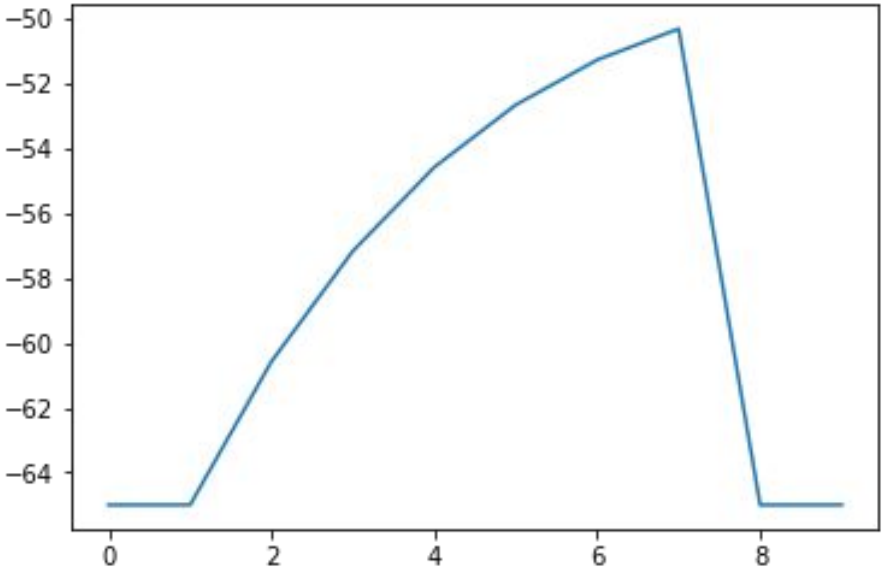


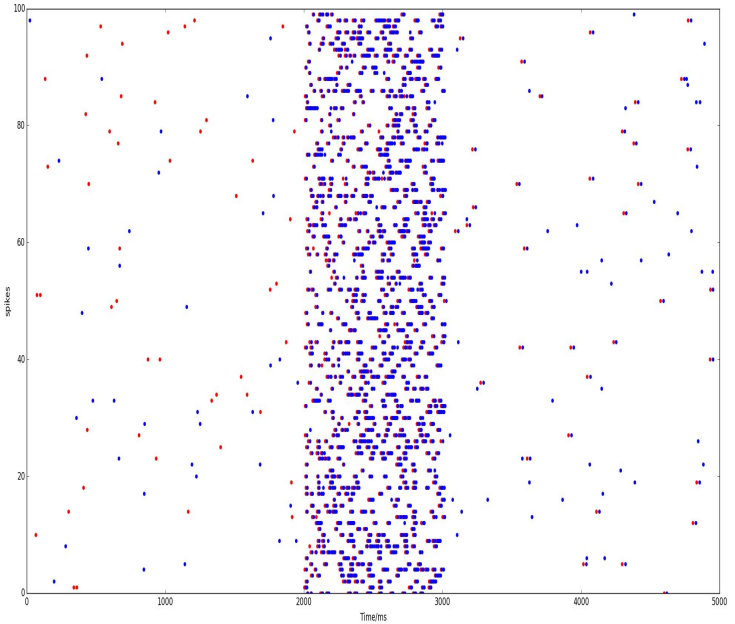

```
p.SpikeSourcePoisson(
    rate=...)
```



PyNN Populations - Recording

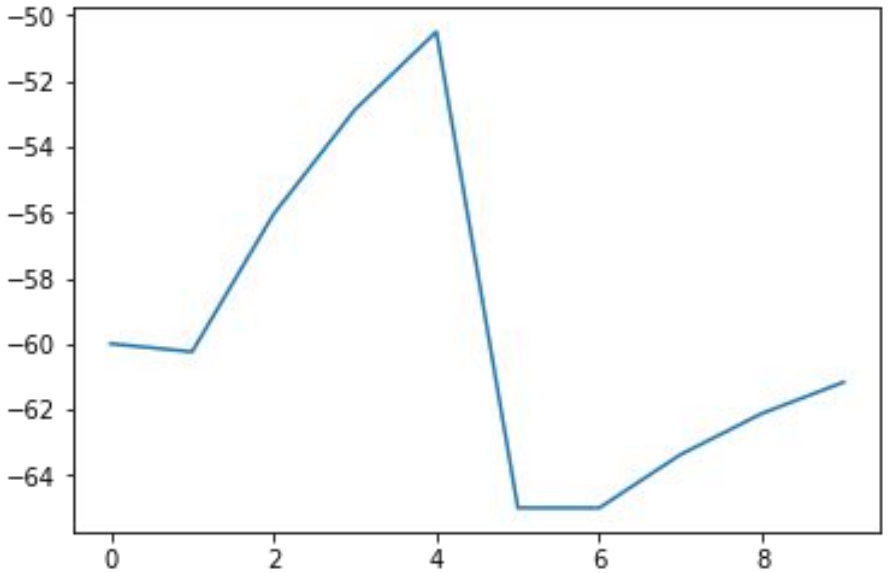
```
pop_1.record(["v", "spikes"])
```





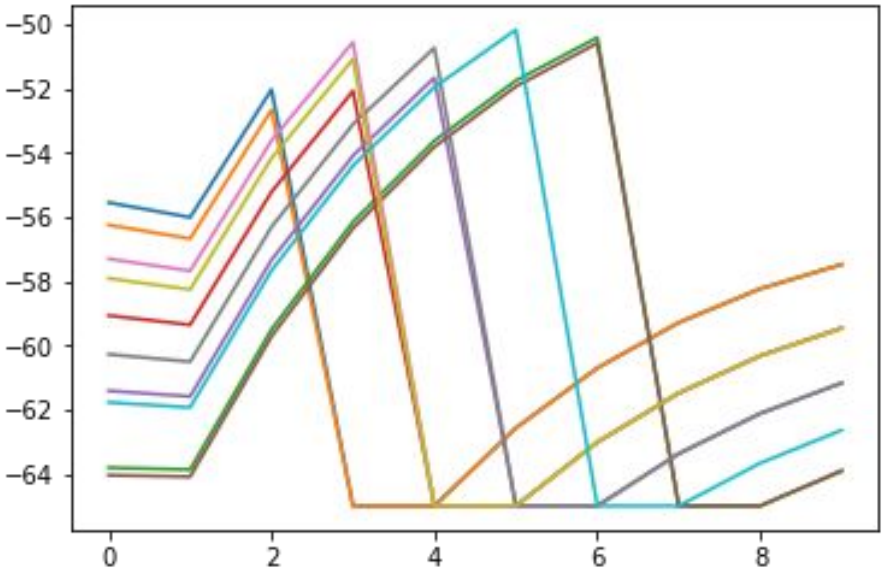
PyNN Populations - Initialize

```
pop_1.initialize(v=-60)
```



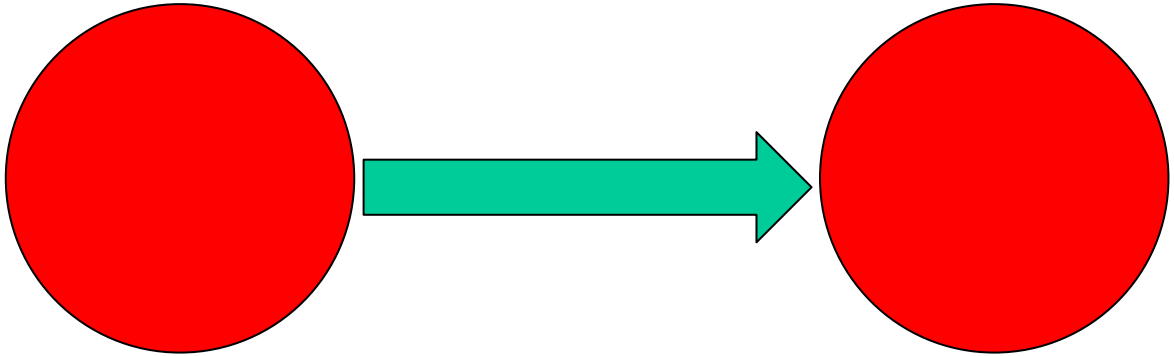
PyNN - Random Parameters

```
pop_1.initialize(v=p.RandomDistribution(
    "uniform", low=-65.0, high=-55.0))
```



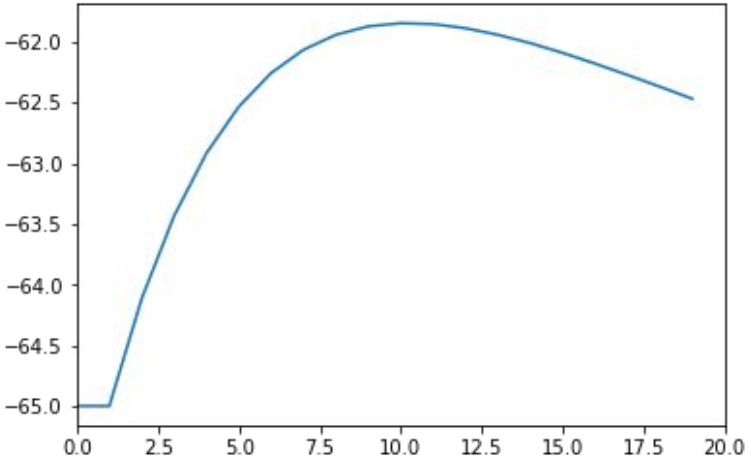
PyNN - Projections

```
proj = p.Projection(
    pop_1, pop_2,
    p.OneToOneConnector(),
    p.StaticSynapse(
        weight=1.0, delay=2.0))
```



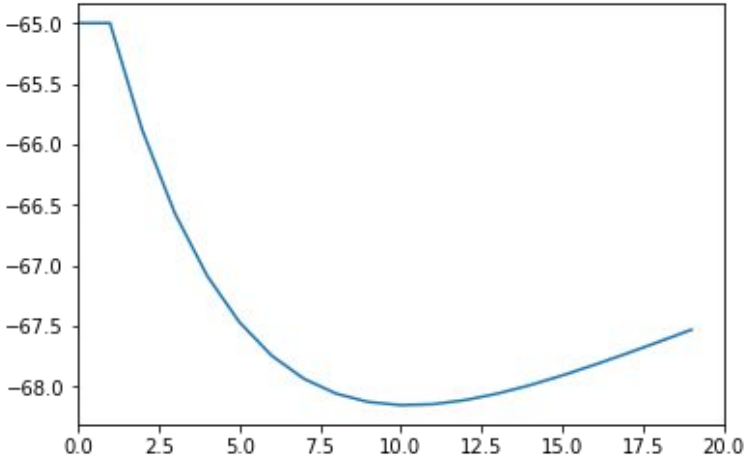
PyNN - Projections

```
proj = p.Projection(
    pop_1, pop_2,
    p.OneToOneConnector(),
    p.StaticSynapse(weight=1.0),
    receptor_type="excitatory")
```



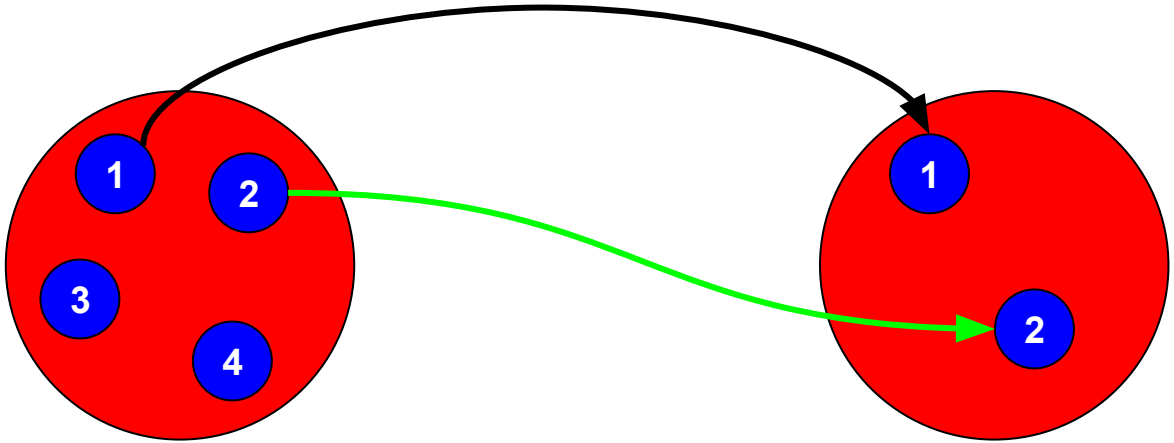
PyNN - Projections

```
proj = p.Projection(
    pop_1, pop_2,
    p.OneToOneConnector(),
    p.StaticSynapse(weight=1.0),
    receptor_type="inhibitory")
```



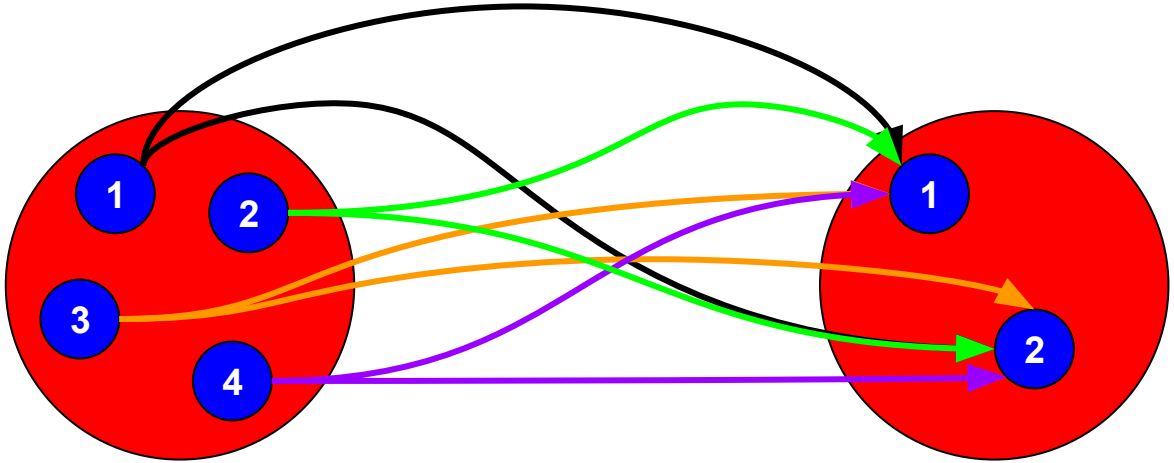
PyNN Projections - Connectors

```
p.OneToOneConnector()
```



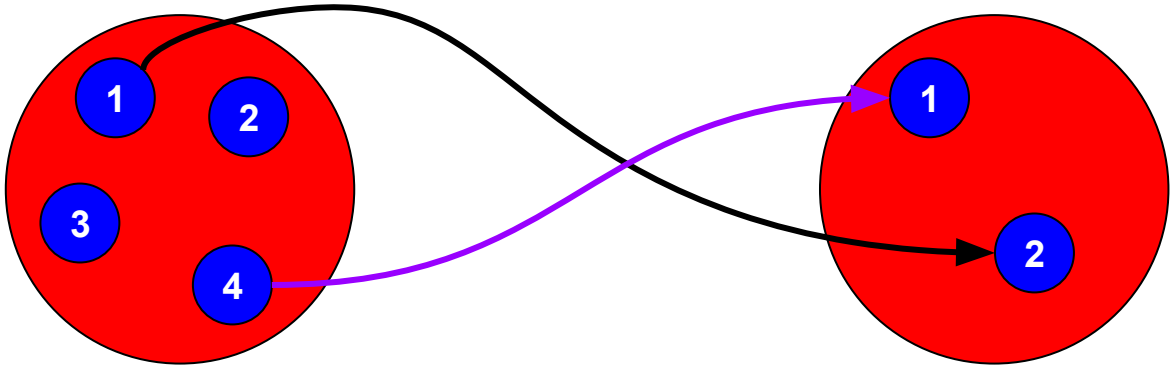
PyNN Projections - Connectors

```
p.AllToAllConnector()
```



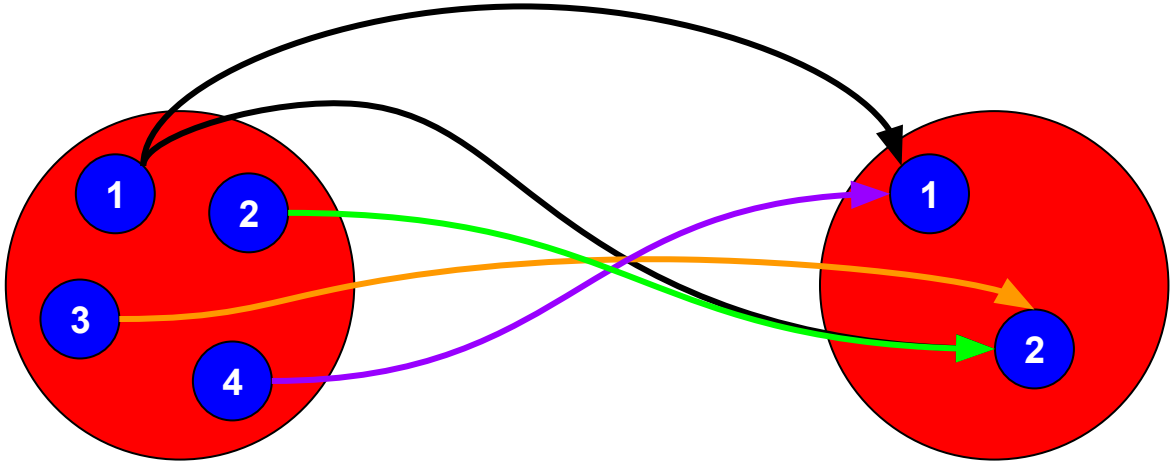
PyNN Projections - Connectors

```
p.FixedProbabilityConnector(p=0.1)
```



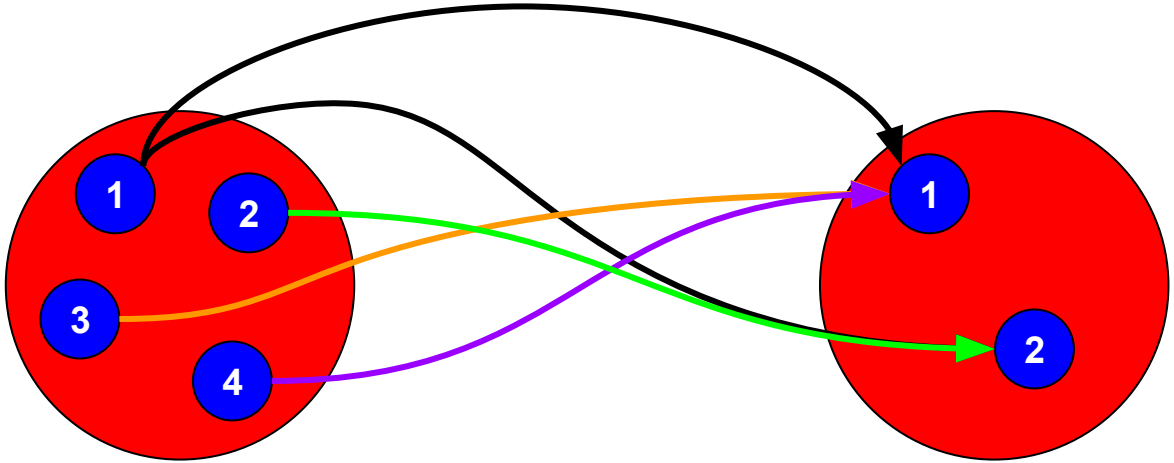
PyNN Projections - Connectors

```
p.FixedProbabilityConnector(p=0.5)
```



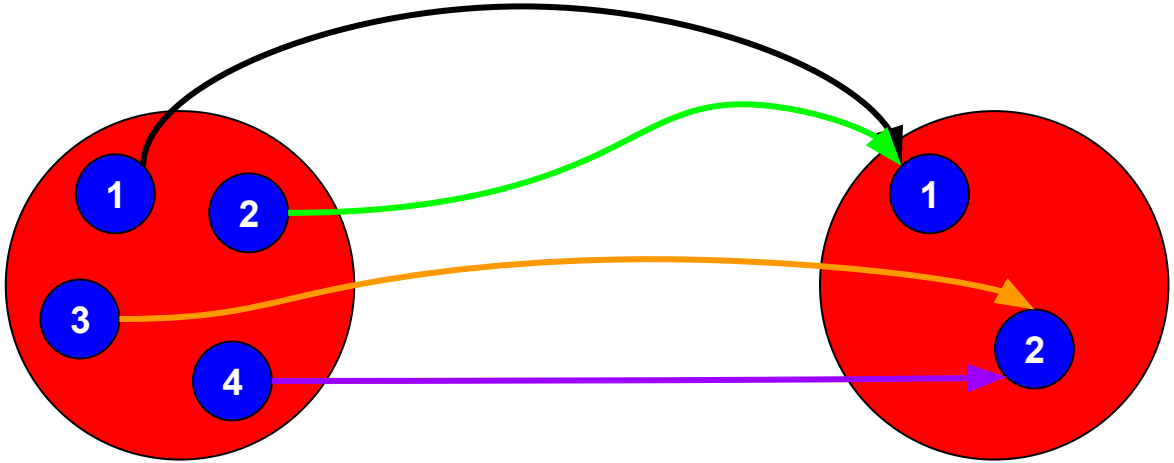
PyNN Projections - Connectors

```
p.FixedTotalNumberConnector(5)
```



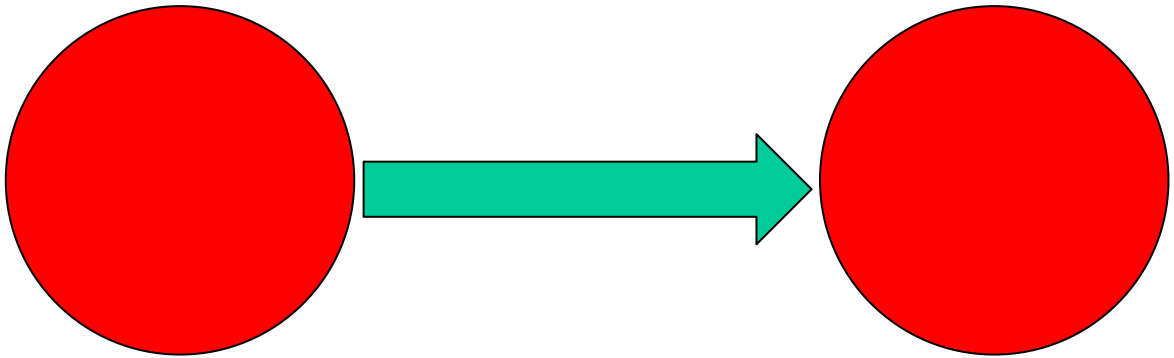
PyNN Projections - Connectors

```
p.FromListConnector(
    [(1, 1), (2, 1), (3, 2), (4, 2)])
```



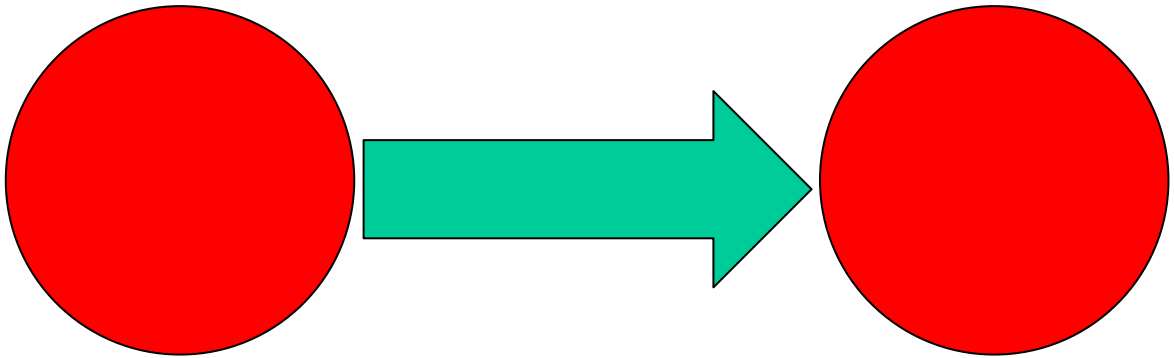
PyNN - Static Synapse Types

```
p.StaticSynapse(weight=1.0, delay=2.0)
```



PyNN - Static Synapse Types

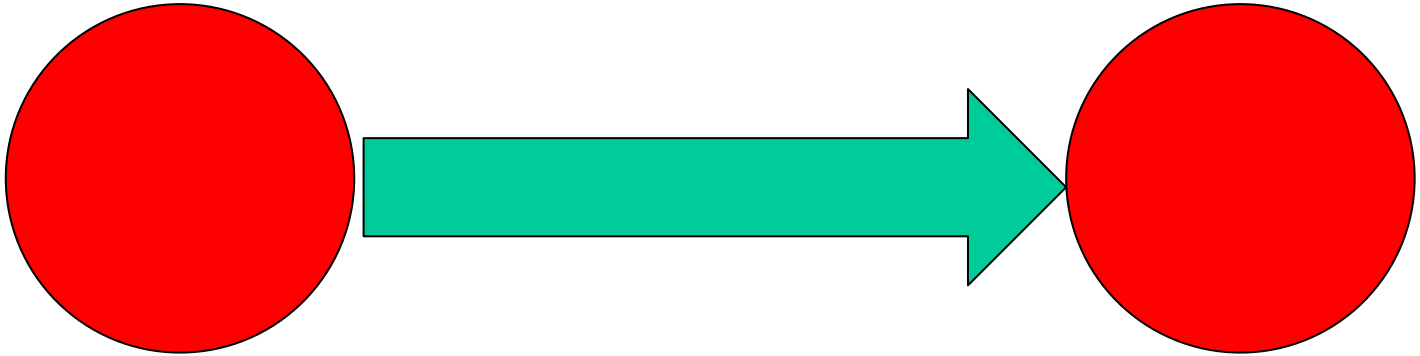
```
p.StaticSynapse(weight=5.0, delay=2.0)
```



PyNN - Static Synapse Types

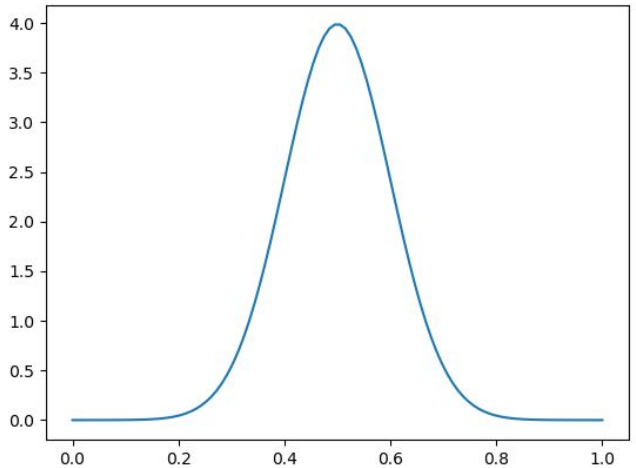
```
p.StaticSynapse(weight=5.0, delay=3.0)
```

(timestep <= delay <= 144 * timestep)



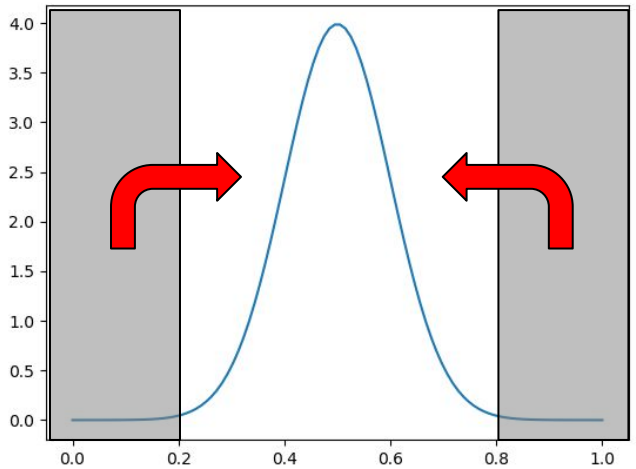
PyNN - Random Weights and Delays

```
weight_dist = p.RandomDistribution(
    “normal”, mu=0.5, sigma=0.1)
p.StaticSynapse(
    weight=weight_dist, delay=3.0)
```



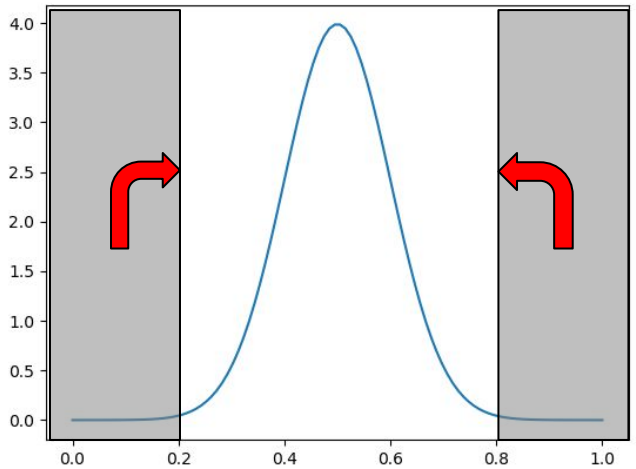
PyNN - Random Weights and Delays

```
weight_dist = p.RandomDistribution(
    “normal_clipped”,
    mu=0.5, sigma=0.1, low=0.2 high=0.8)
```

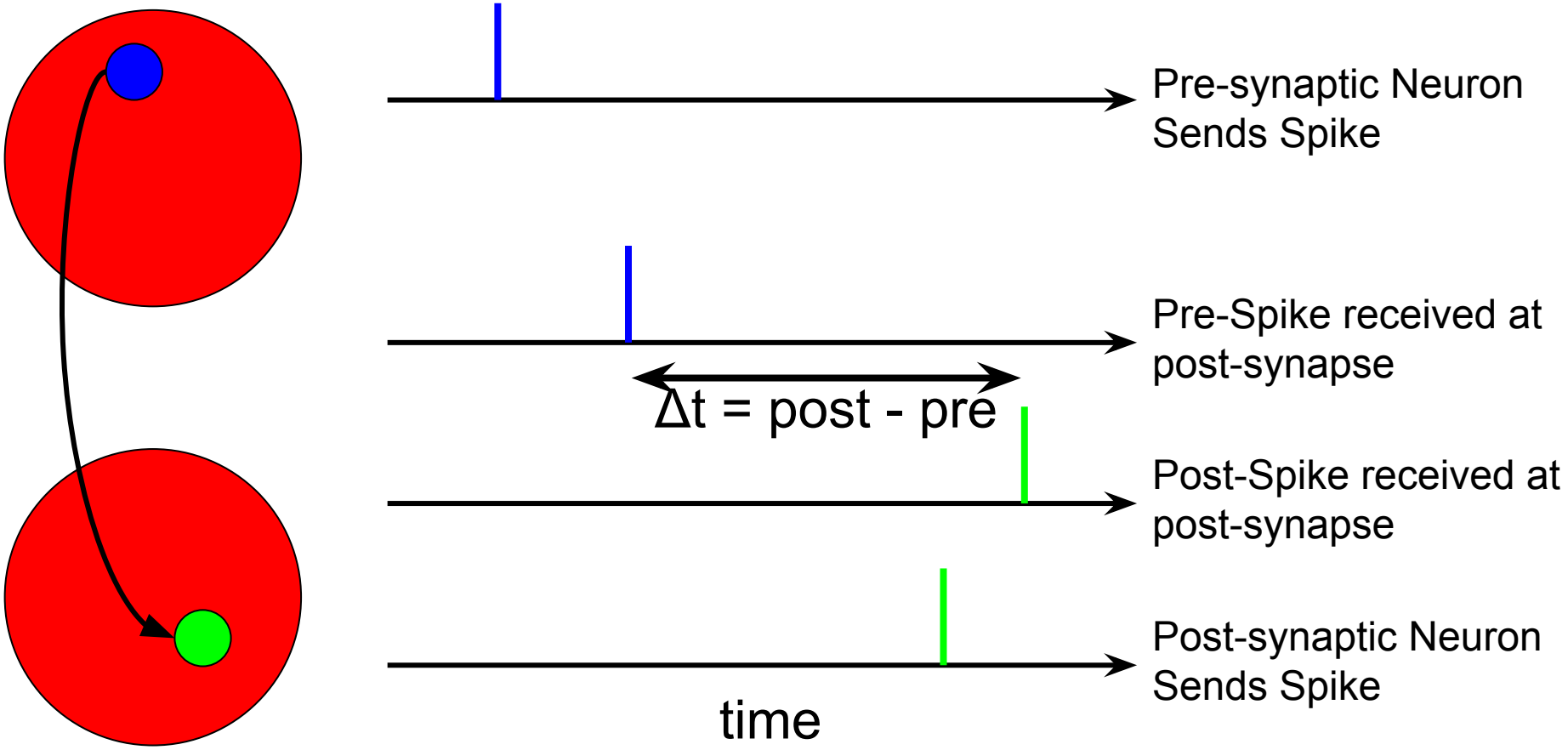


PyNN - Random Weights and Delays

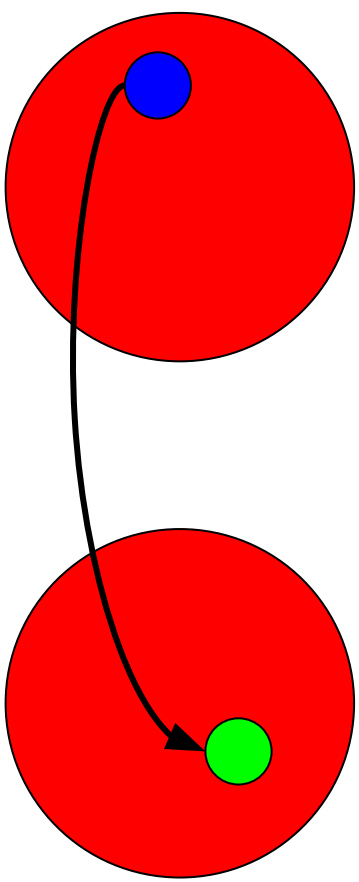
```
weight_dist = p.RandomDistribution(
    “normal_clipped_to_boundary”,
    mu=0.5, sigma=0.1, low=0.2 high=0.8)
```

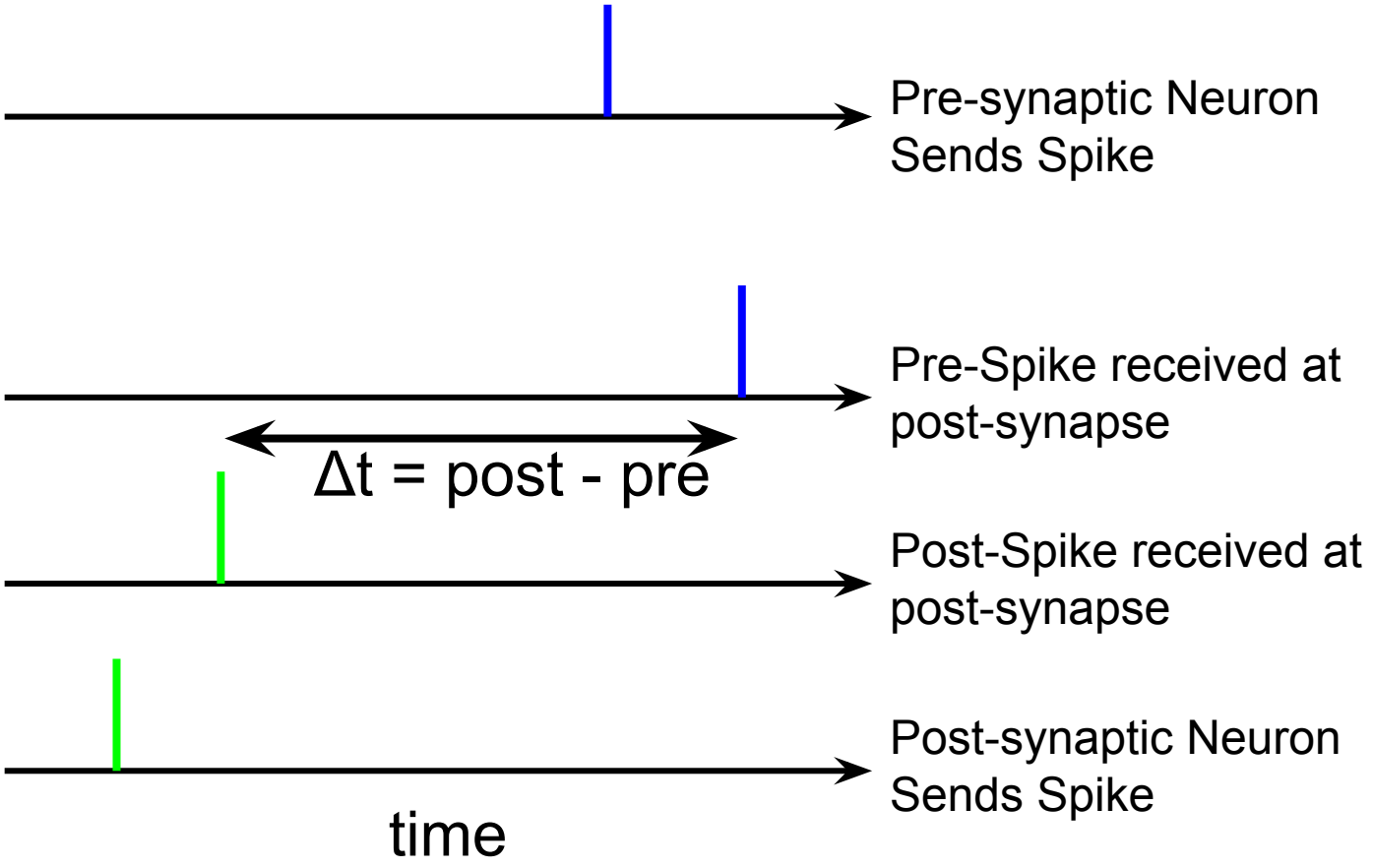


Spike Timing Dependent Plasticity

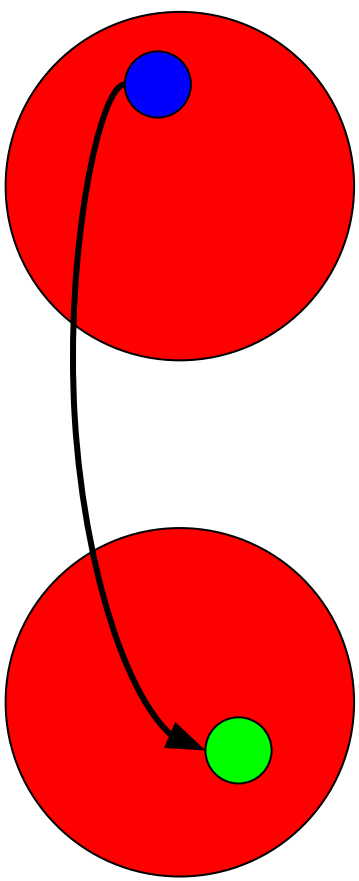


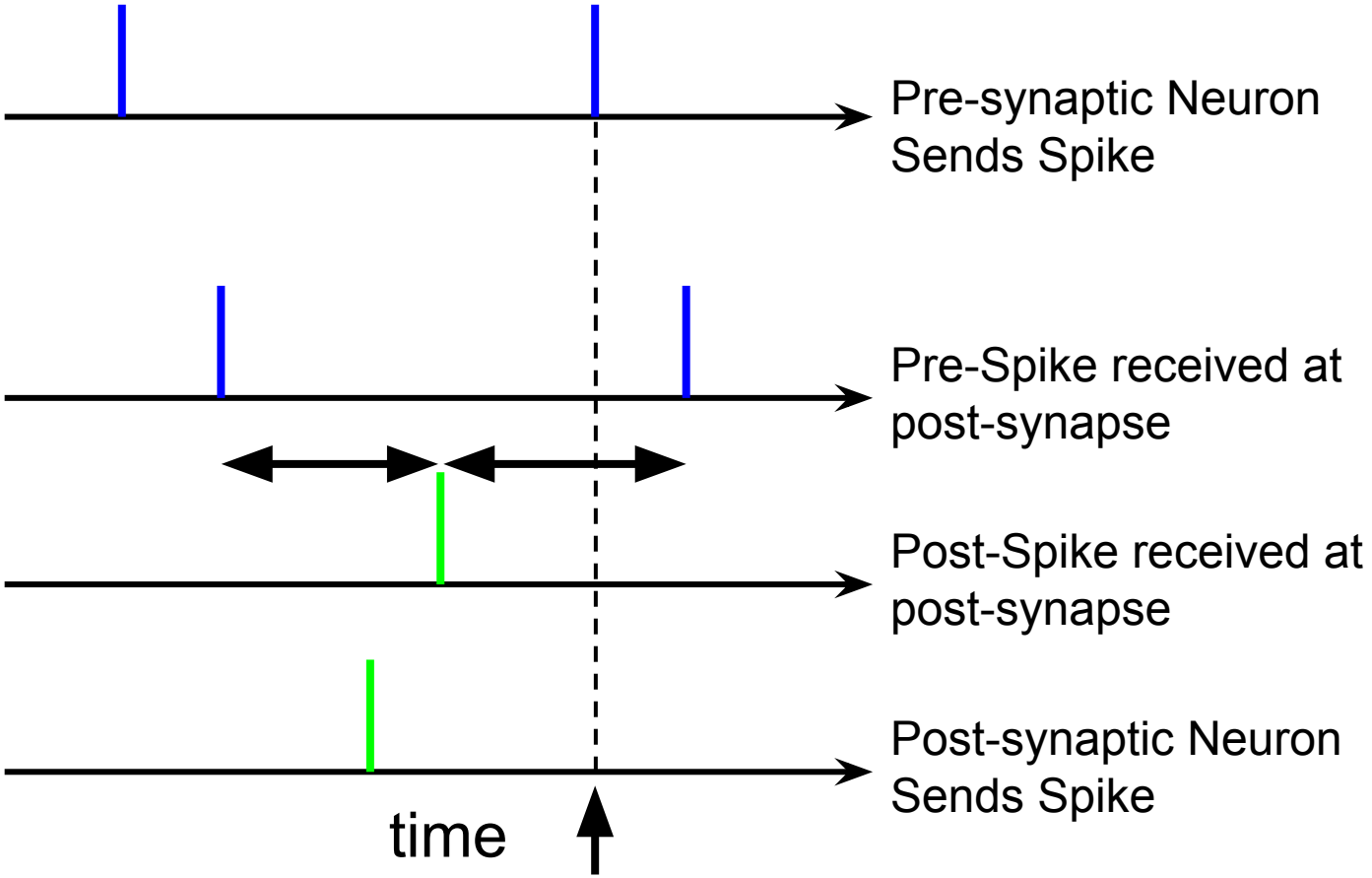
Spike Timing Dependent Plasticity





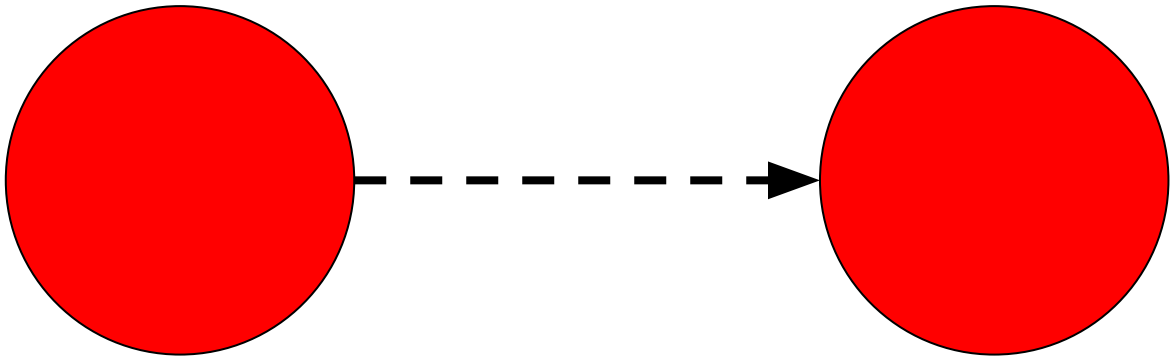
STDP - Deferred Execution





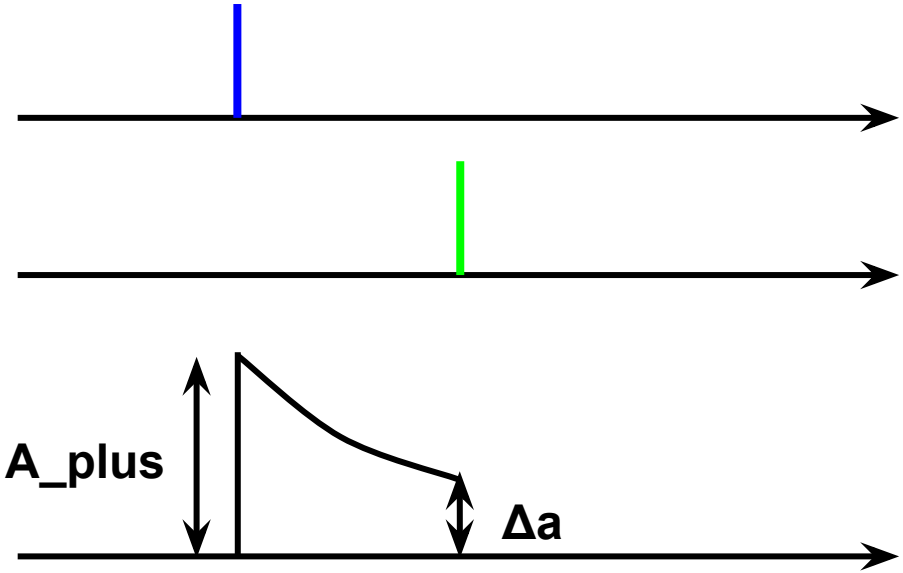
PyNN - STDP Synapse Types

```
p.STDPMechanism(
    timing_dependence=?,
    weight_dependence=?,
    weight=0.0, delay=2.0)
```



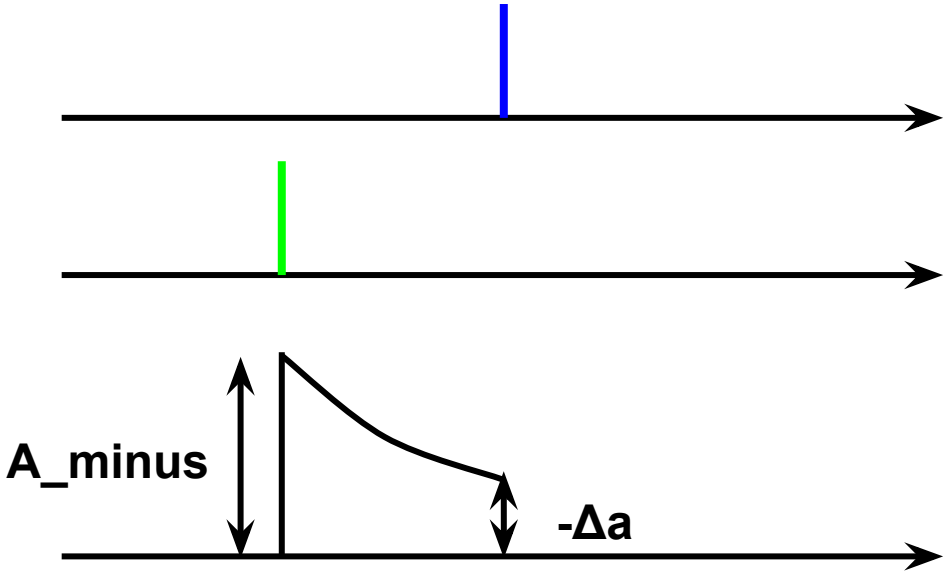
PyNN - Timing Dependence

```
sim.SpikePairRule(tau_plus=20.0, tau_minus=20.0,
                  A_plus=0.5, A_minus=0.5)
```



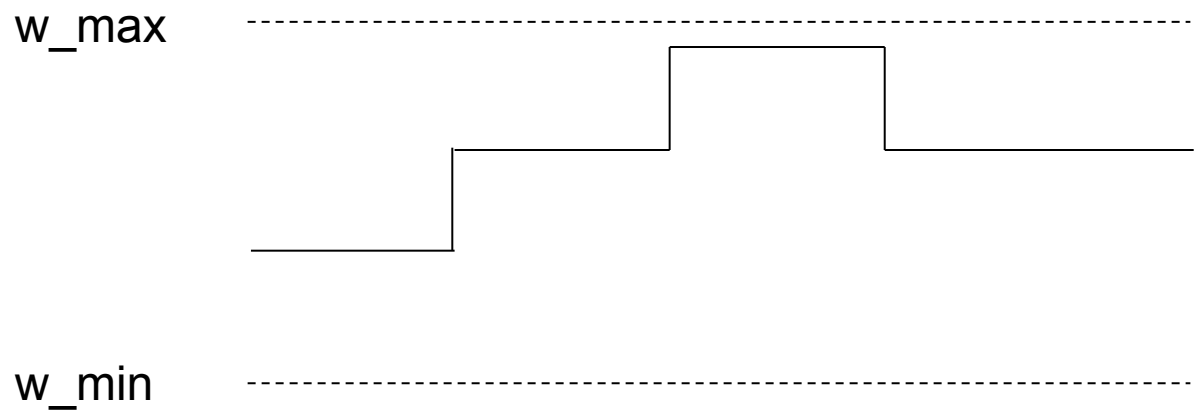
PyNN - Timing Dependence

```
sim.SpikePairRule(tau_plus=20.0, tau_minus=20.0,
                  A_plus=0.5, A_minus=0.5)
```



PyNN - Weight Dependence

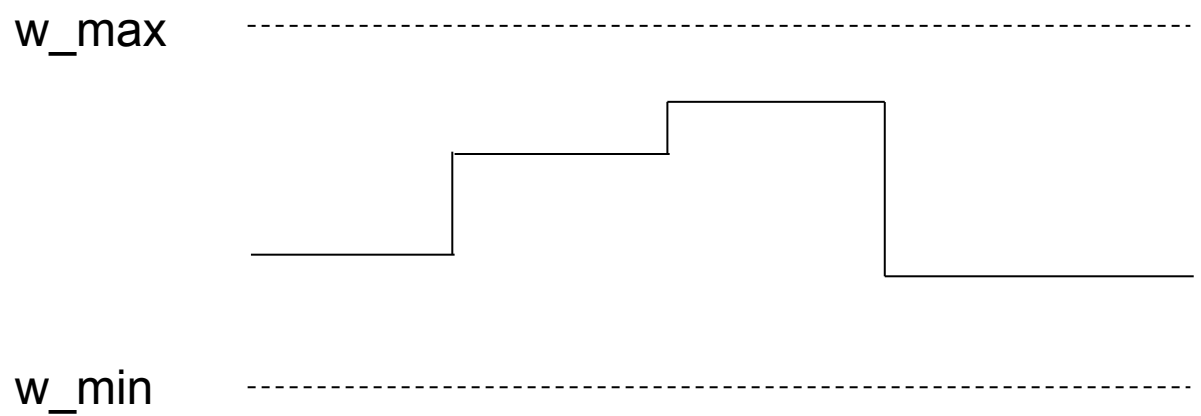
```
sim.AdditiveWeightDependence(w_max=5.0, w_min=0.0)
```



$$\Delta w = \Delta a \, (w\_max - w\_min)$$

PyNN - Weight Dependence

```
sim.MultiplicativeWeightDependence(w_max=5.0,w_min=0.0)
```



$$\Delta w = \Delta a\ (w - w\_min) \text{ if } \Delta a < 0 \text{ (Depression)}$$

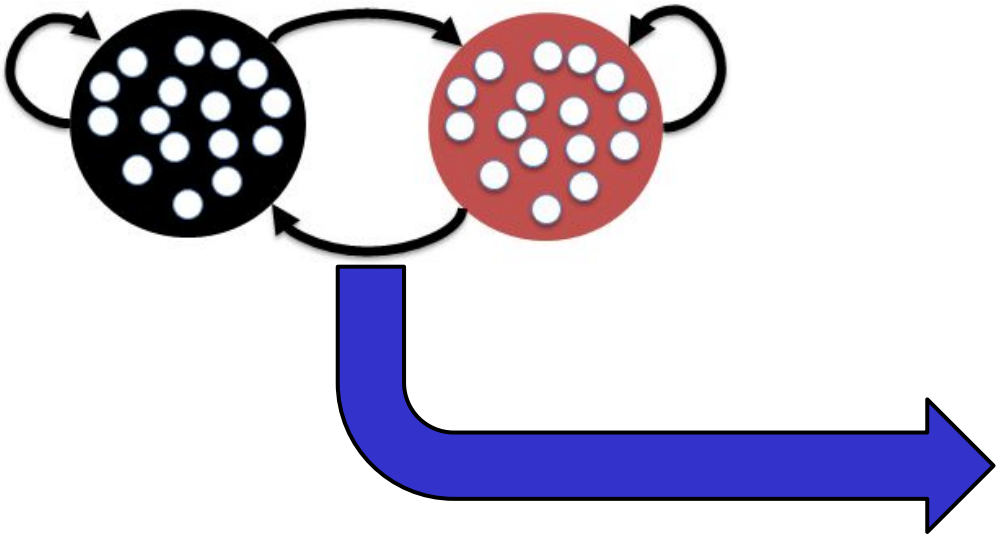
$$\Delta w = \Delta a\ (w\_max - w) \text{ if } \Delta a > 0 \text{ (Potentiation)}$$

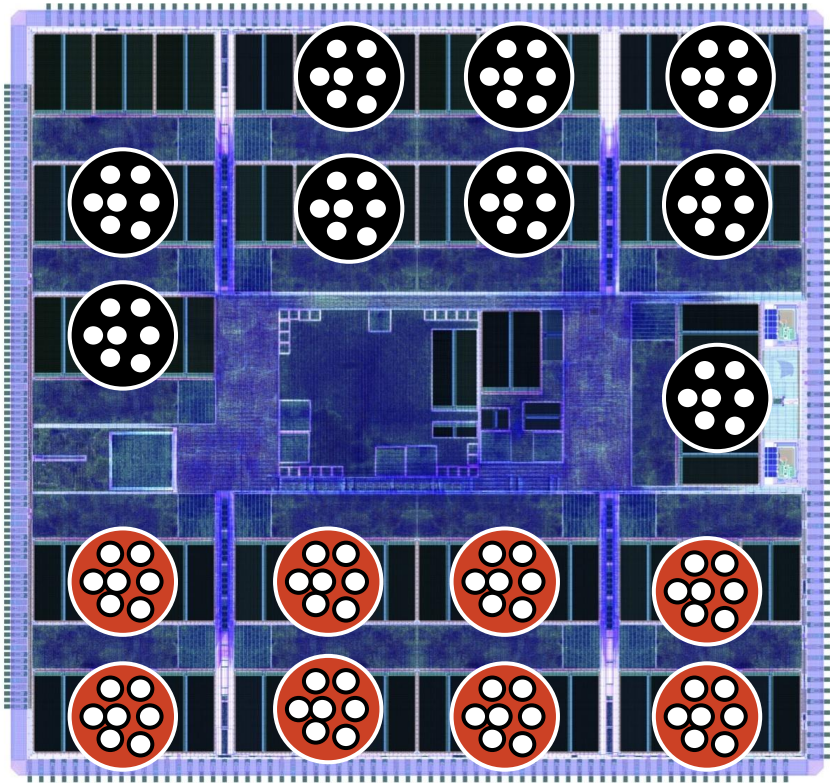
MANCHESTER 1824

Running on SpiNNaker

PyNN - Run

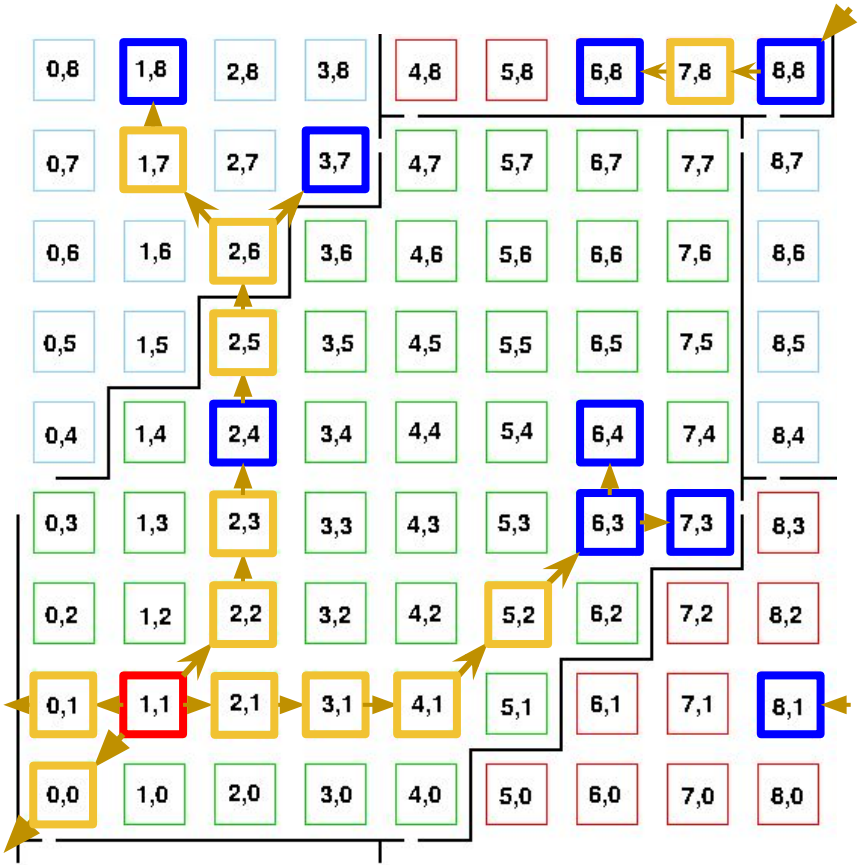
```
p.run(100)
```





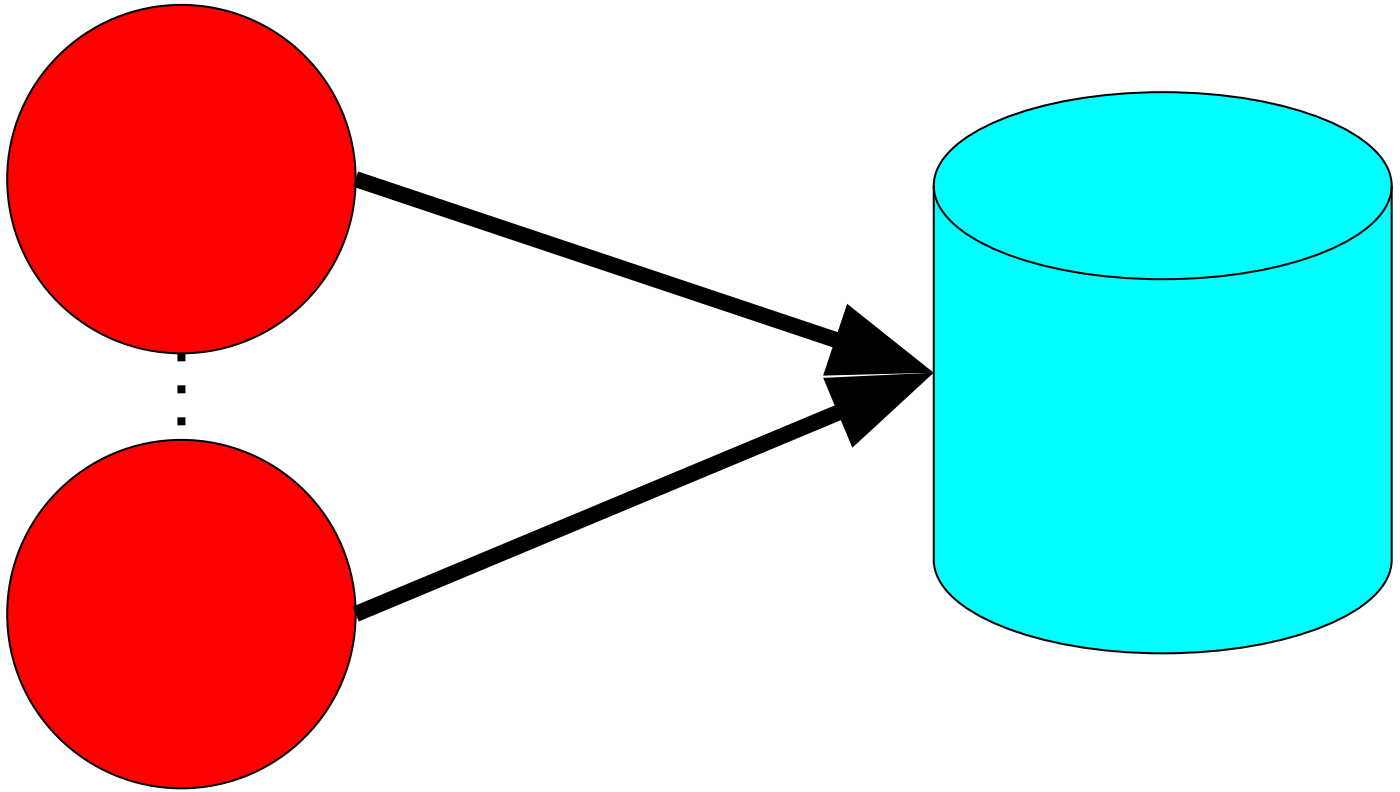
PyNN - Run

```
p.run(100)
```



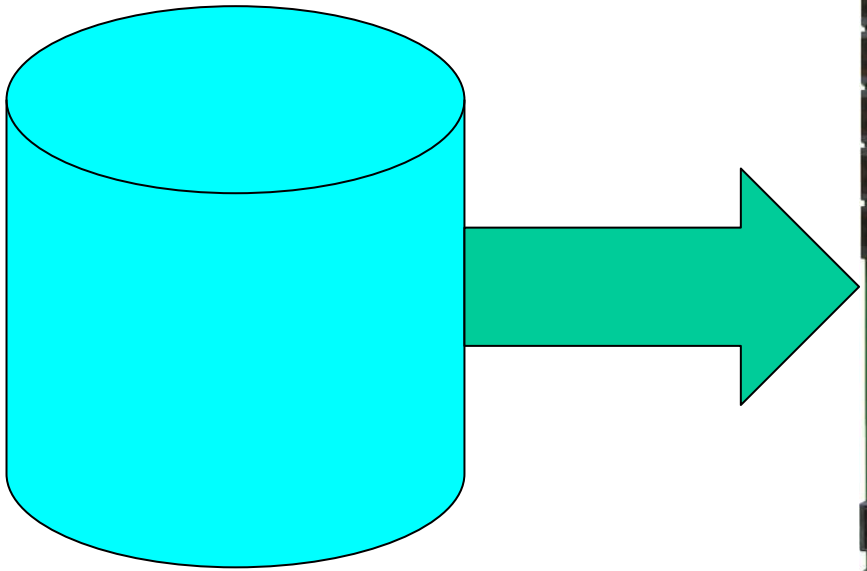
PyNN - Run

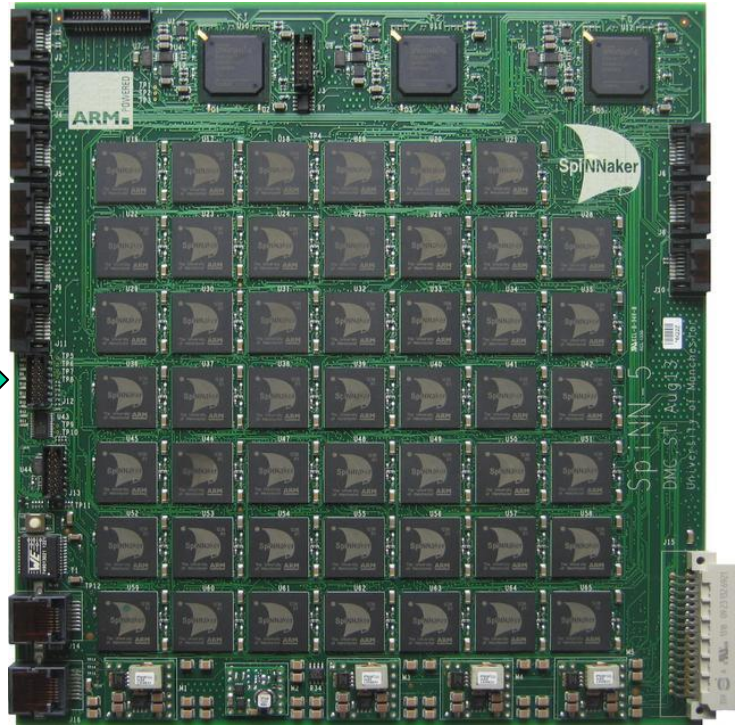
```
p.run(100)
```



PyNN - Run

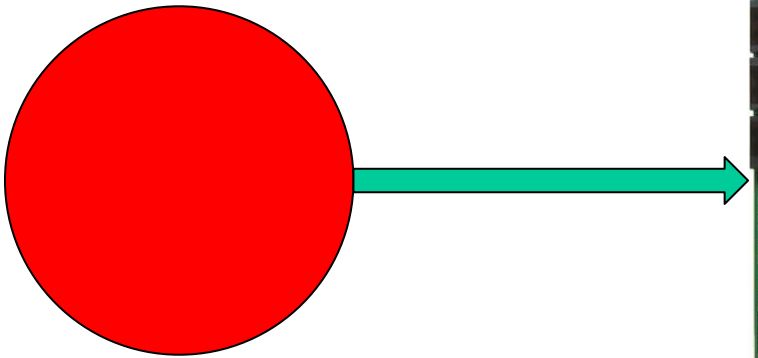
```
p.run(100)
```

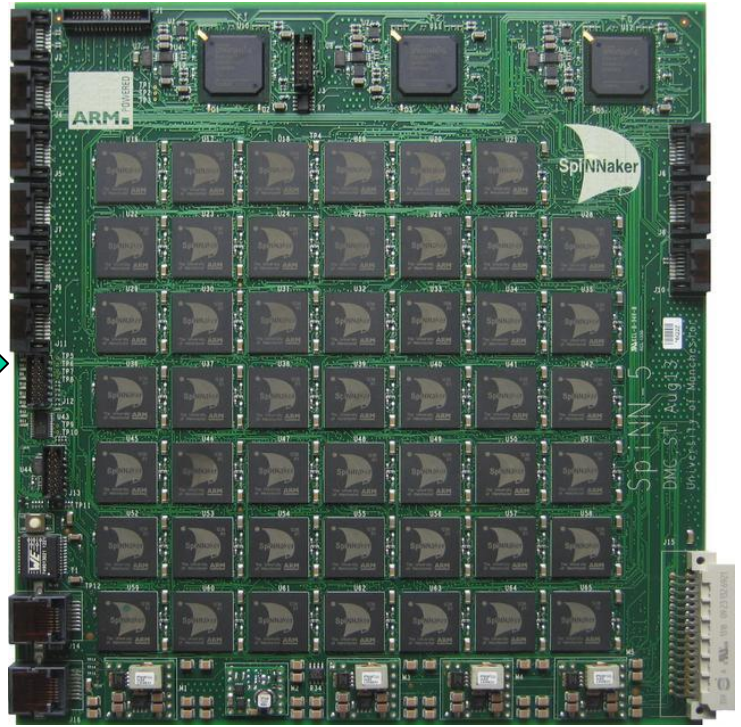




PyNN - Change and Run Again

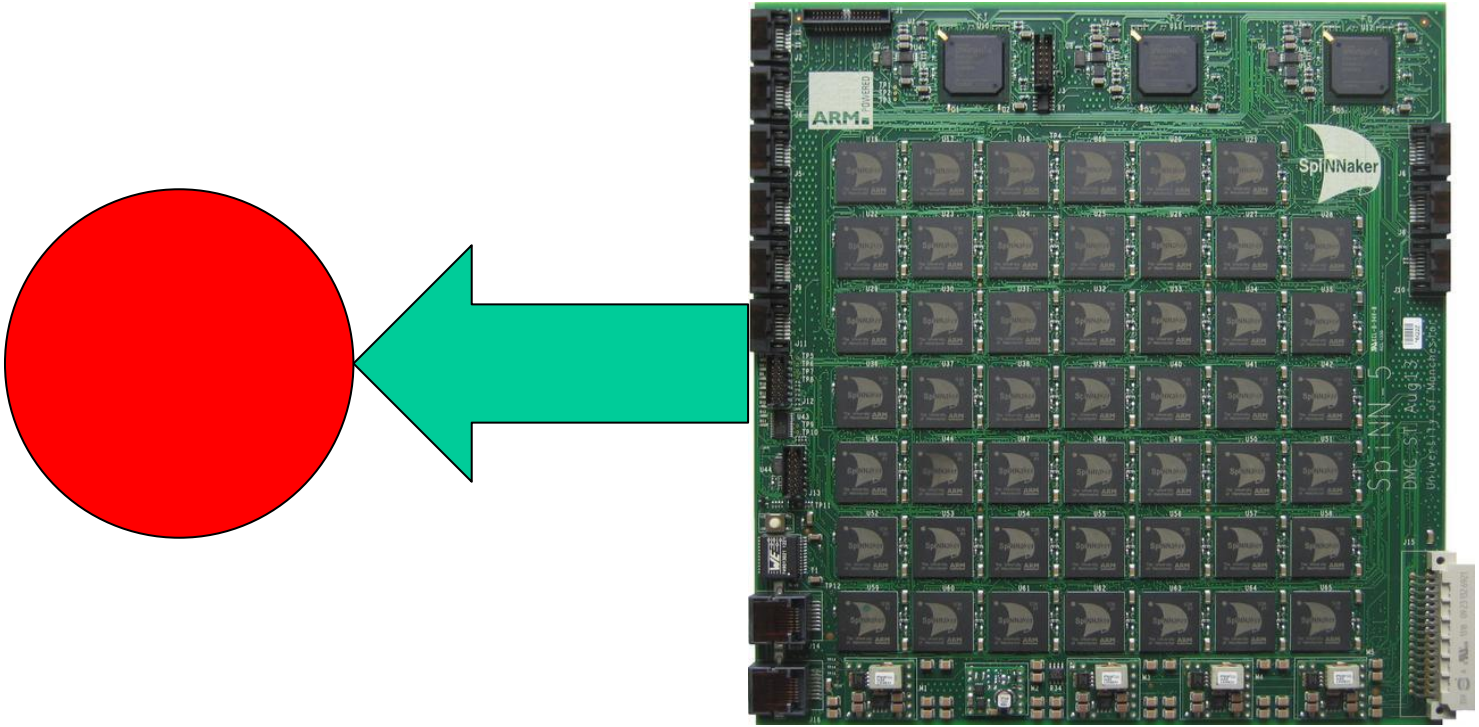
```
pop_1.set(i_offset=5.0)
p.run(50)
```





PyNN - Get Data

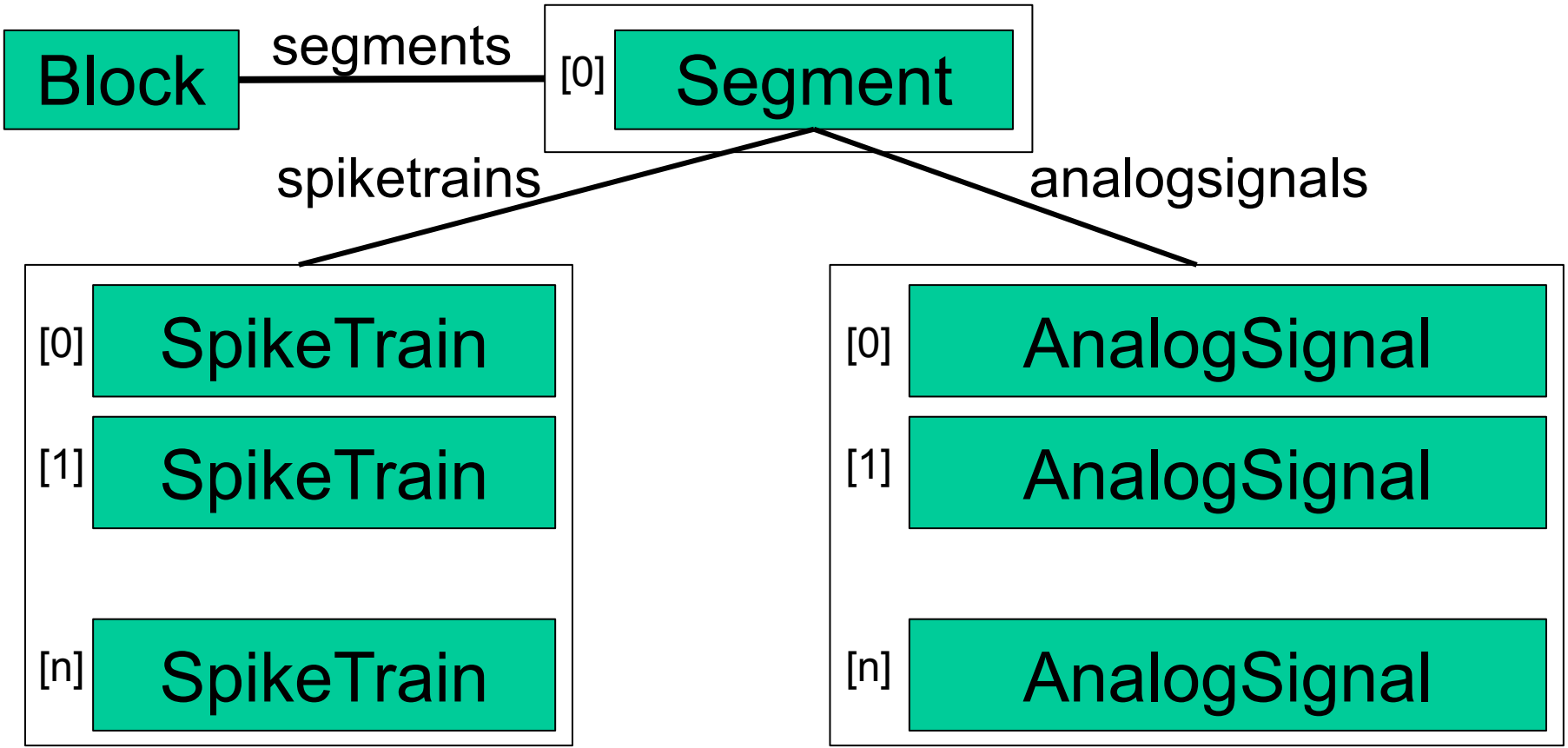
```
data = pop_1.get_data(["v", "spikes"])
```



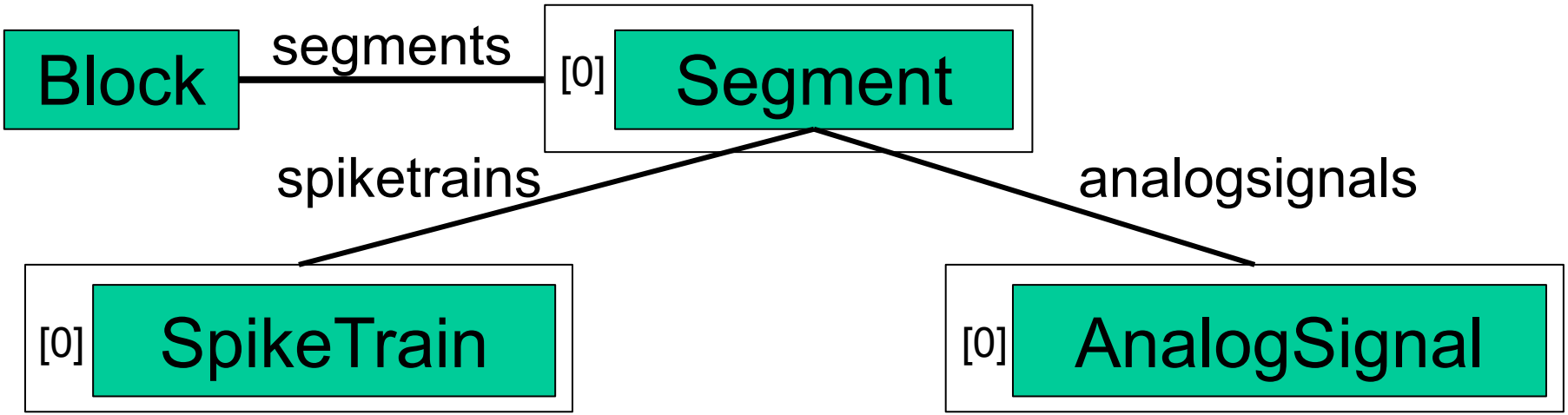
MANCHESTER 1824

Reading Results

PyNN - Neo Data



PyNN - Neo Data

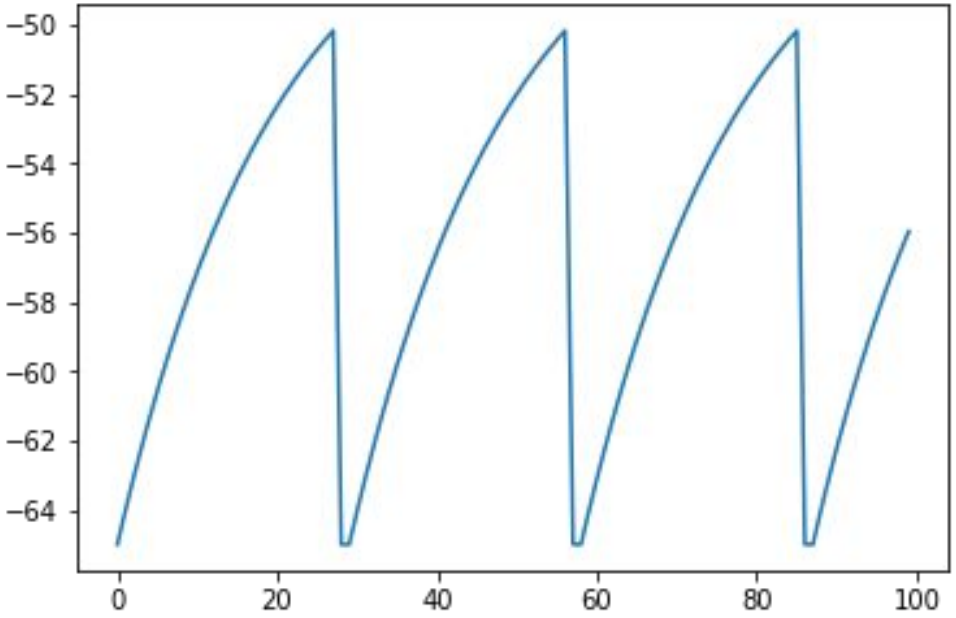



```
data = pop_1.get_data(["v", "spikes"])
v = data.segments[0].analogsignals
V = data.segments[0].filter(name="v")[0]
spikes = data.segments[0].spiketrains
```

PyNN - Plotting

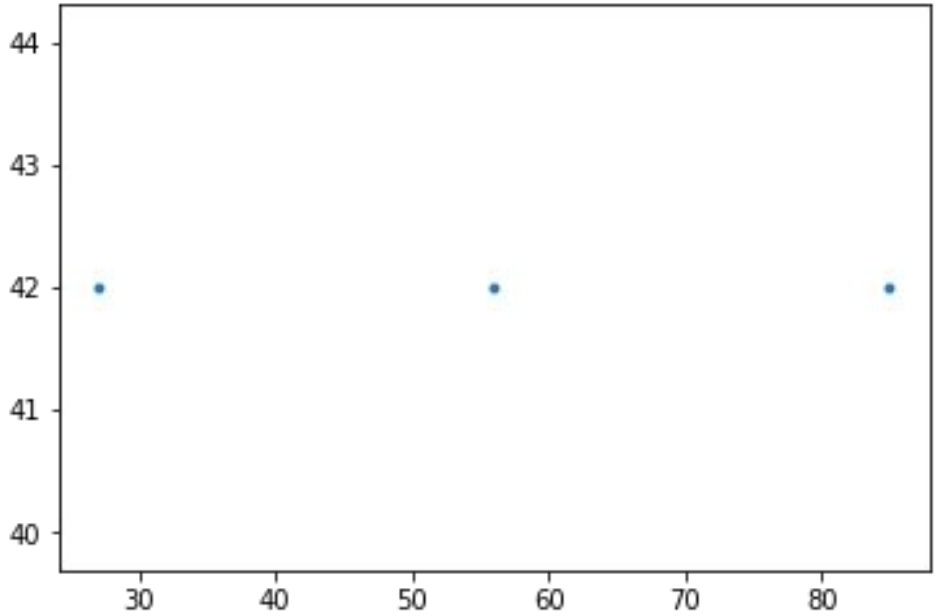
```
import matplotlib.pyplot as plt

plt.figure()
plt.plot(v[0].times, v[0])
plt.show()
```



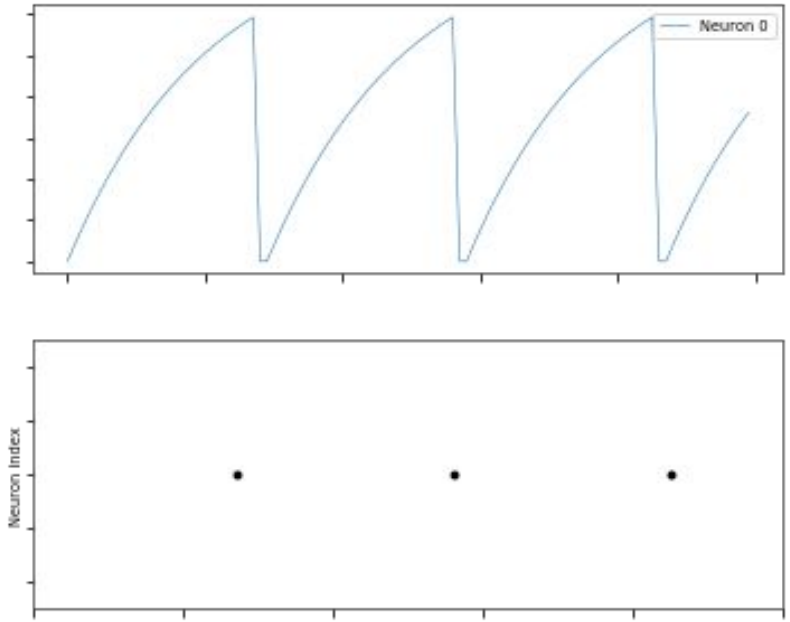
PyNN - Plotting

```
plt.figure()
y = [1 for i in range(len(spikes[0]))]
plt.plot(spikes[0], y, “.”)
plt.show()
```



PyNN - Plotting Neo Directly

```
from pyNN.utility.plotting import Figure, Panel
Figure(
    Panel(*data.segments[0].analogsignals),
    Panel(data.segments[0].spiketrains)
)
```



PyNN - Get Weights and Delays

```
synapses = proj.get(
    ["weight", "delay"], "list")
```

```
array([(0, 5, 0.756, 1.), (0, 6, 0.316, 1.), (0, 7, 0.885, 2.),
       (0, 8, 0.421, 1.), (1, 4, 0.618, 1.), (1, 7, 0.438, 1.),
       (1, 9, 1.607, 1.), (2, 0, 0.129, 1.), (2, 2, 1.055, 1.),
       (2, 3, 1.319, 1.), (2, 9, 0.422, 1.), (3, 1, 0.328, 1.),
       (3, 3, 0.456, 1.), (3, 6, 0.566, 1.), (4, 0, 1.046, 1.),
       (4, 1, 1.199, 1.), (4, 2, 0.831, 1.), (5, 0, 1.643, 1.),
       (5, 2, 1.165, 1.), (5, 3, 0.902, 1.), (5, 5, 1.627, 1.),
       (6, 0, 2.143, 1.), (6, 5, 0.635, 1.), (6, 7, 0.704, 1.),
       (7, 0, 1.914, 1.), (7, 4, 0.289, 1.), (7, 5, 2.058, 1.),
       (7, 6, 0.428, 2.), (7, 7, 0.639, 1.), (7, 9, 0.616, 2.),
       (8, 0, 1.039, 1.), (8, 1, 0.576, 1.), (8, 4, 1.563, 2.),
       (8, 8, 0.995, 1.), (9, 0, 1.686, 1.), (9, 9, 0.631, 2.)]
```

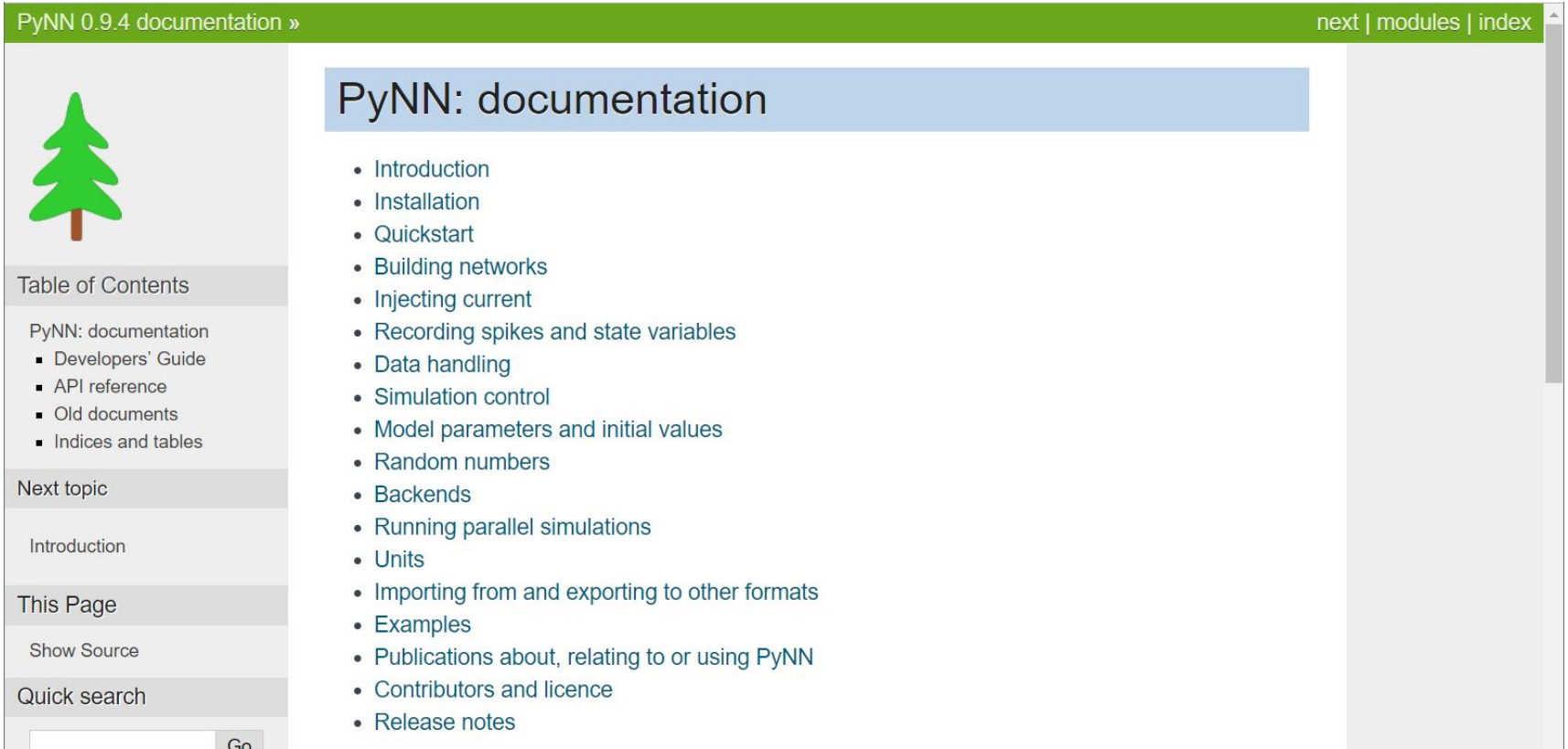
PyNN - Get Weights and Delays

```
synapses = proj.get(
    "weight", "array")
```

```
array([[  nan,   nan,   nan,   nan,   nan, 0.756, 0.316, 0.885, 0.421,   nan],
       [  nan,   nan,   nan,   nan, 0.618,   nan,   nan, 0.438,   nan, 1.607],
       [0.129,   nan, 1.055, 1.319,   nan,   nan,   nan,   nan,   nan, 0.422],
       [  nan, 0.328,   nan, 0.456,   nan,   nan, 0.566,   nan,   nan,   nan],
       [1.046, 1.199, 0.831,   nan,   nan,   nan,   nan,   nan,   nan,   nan],
       [1.643,   nan, 1.165, 0.902,   nan, 1.627,   nan,   nan,   nan,   nan],
       [2.143,   nan,   nan,   nan,   nan, 0.635,   nan, 0.704,   nan,   nan],
       [1.914,   nan,   nan,   nan, 0.289, 2.058, 0.428, 0.639,   nan, 0.616],
       [1.039, 0.576,   nan,   nan, 1.563,   nan,   nan,   nan, 0.995,   nan],
       [1.686,   nan,   nan,   nan,   nan,   nan,   nan,   nan,   nan, 0.631]])
```

PyNN Documentation

http://neuralensemble.org/docs/PyNN/



PyNN 0.9.4 documentation » next | modules | index

PyNN: documentation

- Introduction
- Installation
- Quickstart
- Building networks
- Injecting current
- Recording spikes and state variables
- Data handling
- Simulation control
- Model parameters and initial values
- Random numbers
- Backends
- Running parallel simulations
- Units
- Importing from and exporting to other formats
- Examples
- Publications about, relating to or using PyNN
- Contributors and licence
- Release notes

Table of Contents

PyNN: documentation
- Developers' Guide
- API reference
- Old documents
- Indices and tables

Next topic

Introduction

This Page

Show Source

Quick search

Go

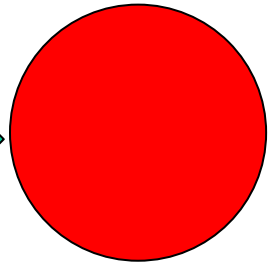
MANCHESTER 1824

Live Input and Output

Input from Environment: Spikes

send_spikes

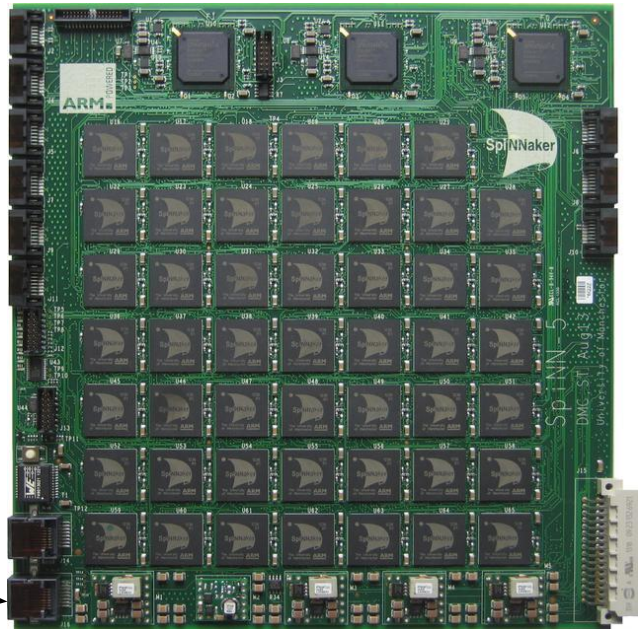
SpikeInjector
label="injector"



```
send_spikes("injector", [0])
```

```
SpynnakerLiveSpikesConnection(
    send_labels=["injector"])
```

Multicast Key(s)
(Spike)

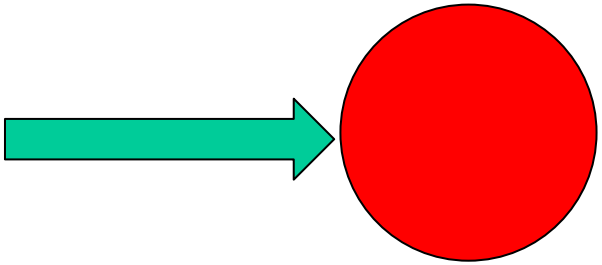


Input from Environment: Rates

add_poisson_live_rate_control

set_rates

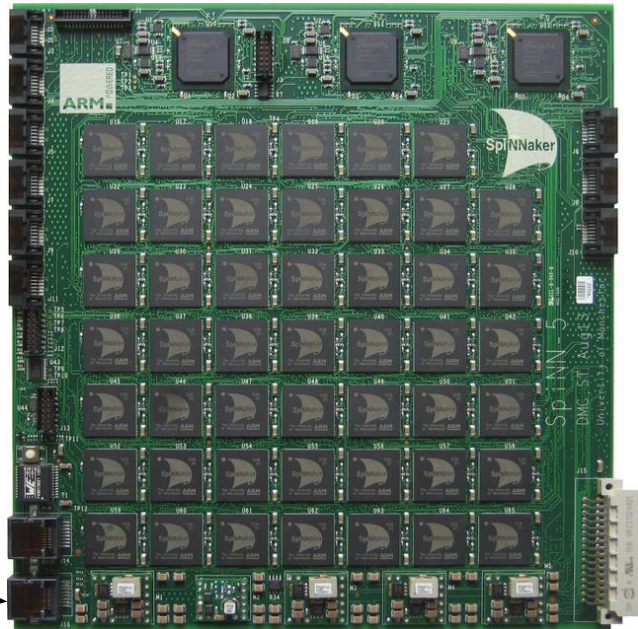
SpikeSourcePoisson
label="input"



```
set_rates("input", [(0, 10)])
```

```
SpynnakerPoissonControlConnection(
    poisson_labels=["input"])
```

Multicast Key(s)
and Payload(s)



Output to Environment: Spikes

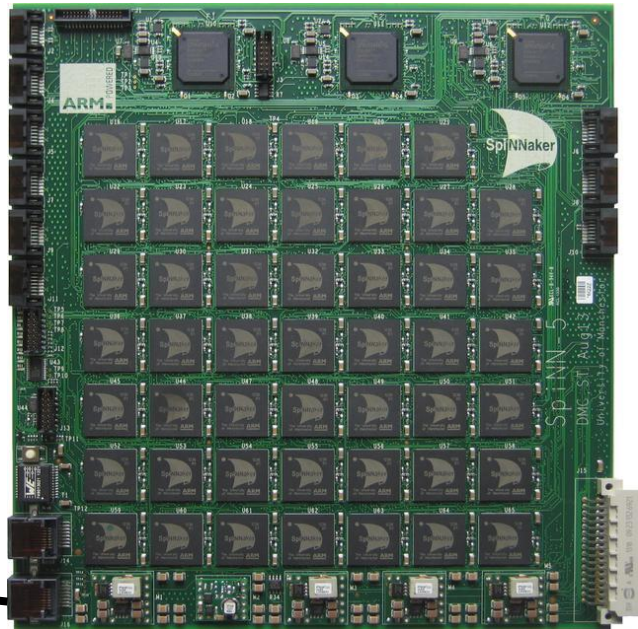
activate_live_output_for

recv

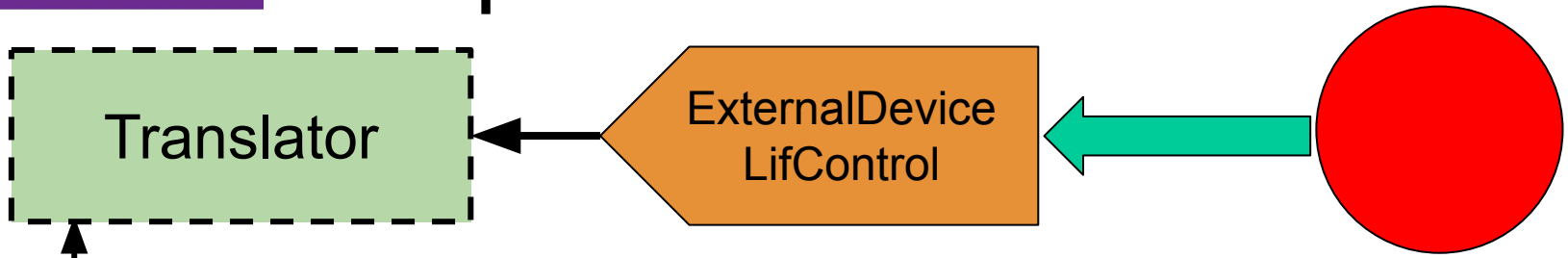
recv("pop", time, neuron_ids)

```
SpynnakerLiveSpikesConnection(
    receive_labels=["pop"])
```

Multicast Key(s)
(Spike)

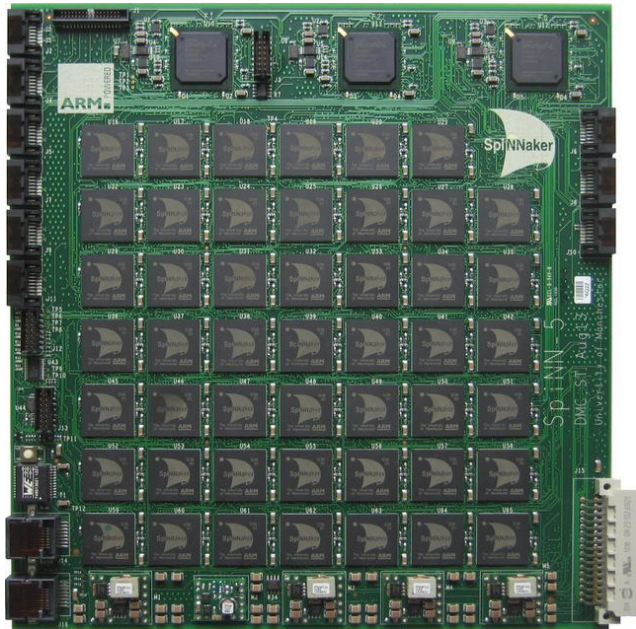


Output to Environment: Voltage

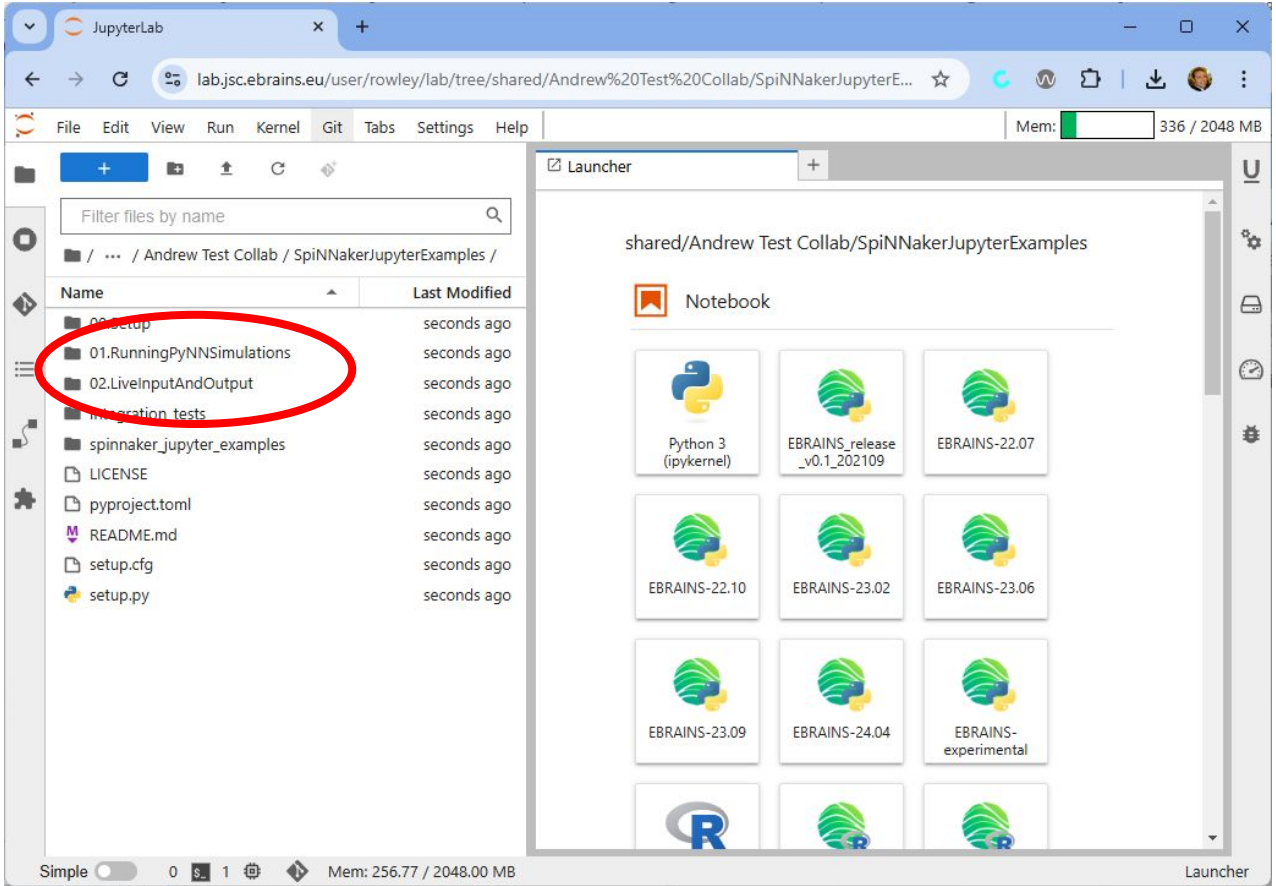



```
translate_control_packet(pkt)
```

```
EthernetControlPopulation(
    lif_device_model)
```



SpiNNaker Tutorials



MANCHESTER 1824

SpiNNaker Tutorials on Jupyter

https://lab.ebrains.eu/

https://github.com/SpiNNakerManchester/SpiNNakerJupyterExamples

01.RunningPyNNSimulations
02.LiveInputAndOutput

PyNN Documentation:
http://neuralensemble.org/docs/PyNN/