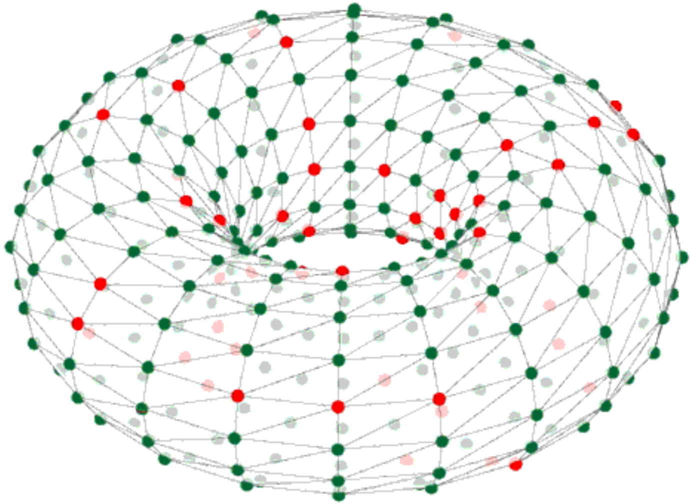
Running PyNN Simulations on SpiNNaker



Andrew Rowley

SpiNNaker Workshop

January 2015

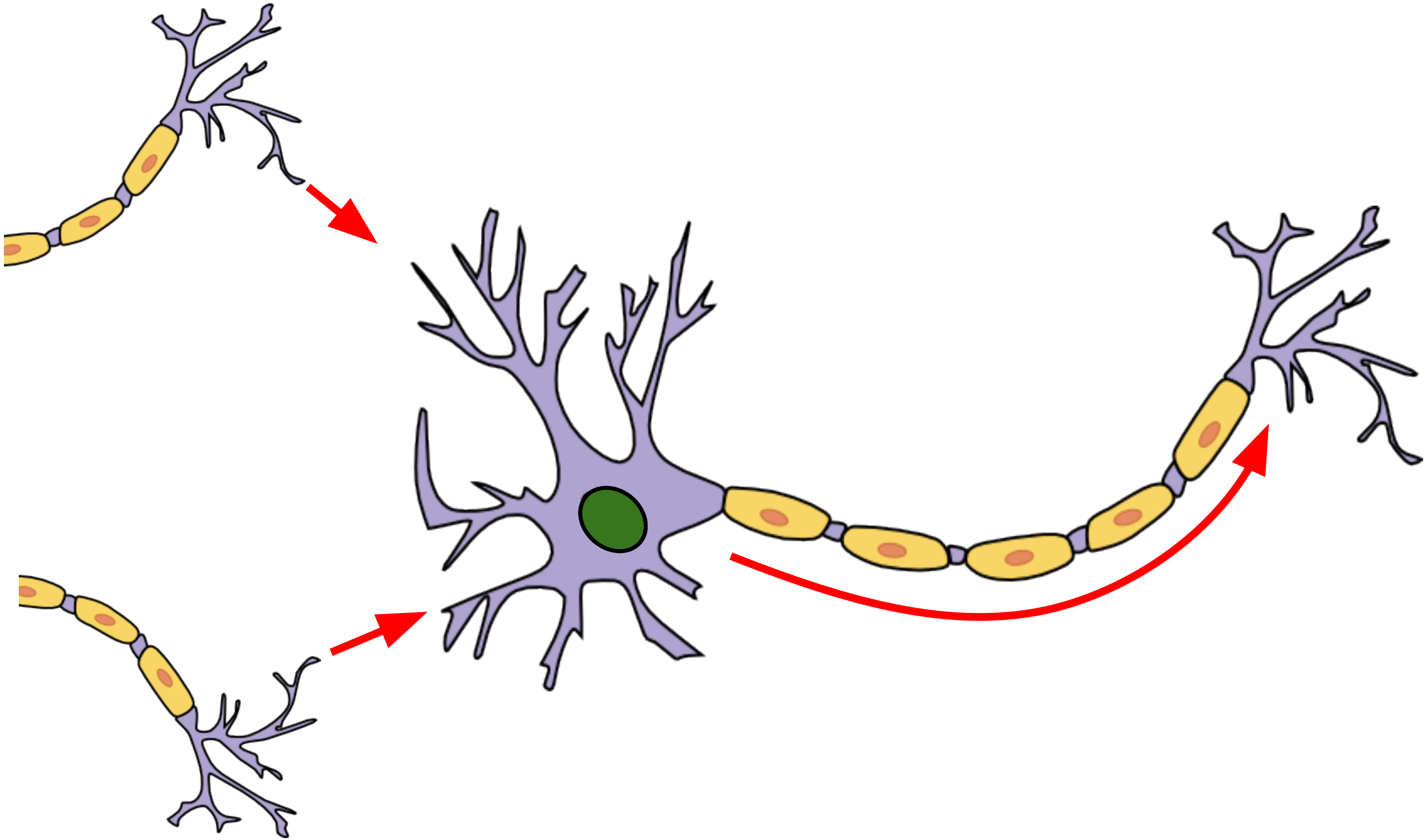
European Research Council
Established by the European Commission

Human Brain Project

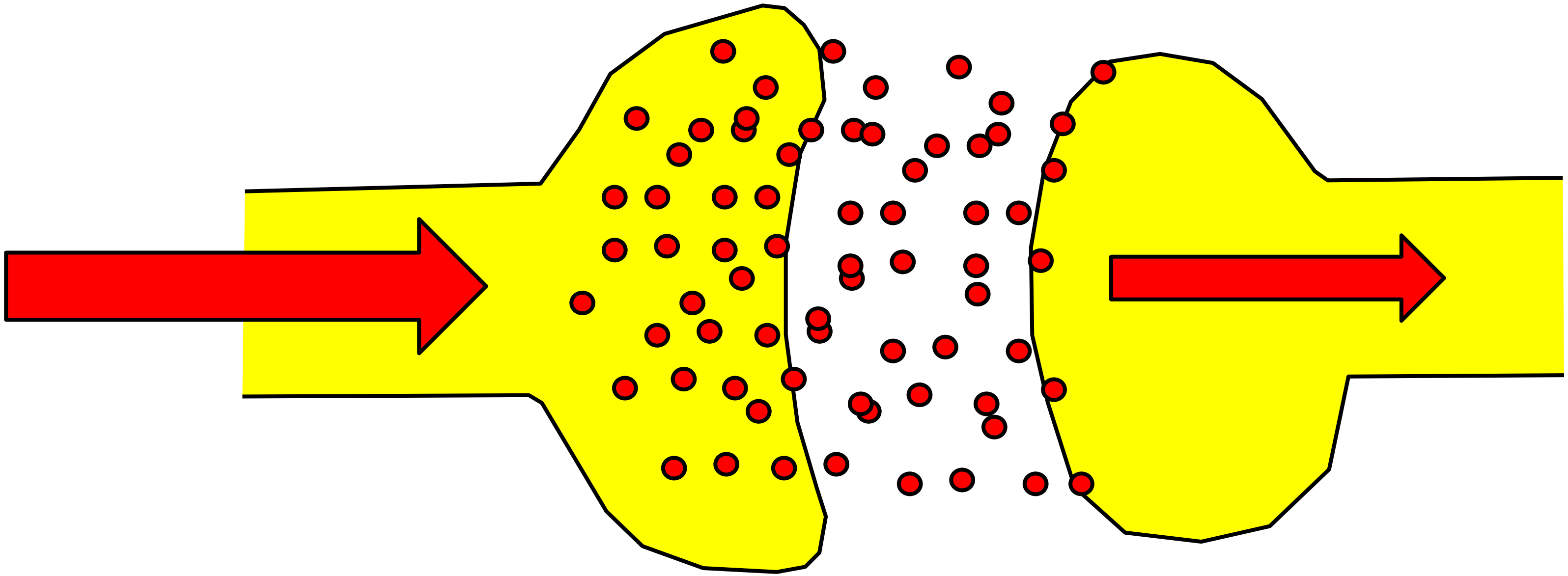
EPSRC

SpiNNaker

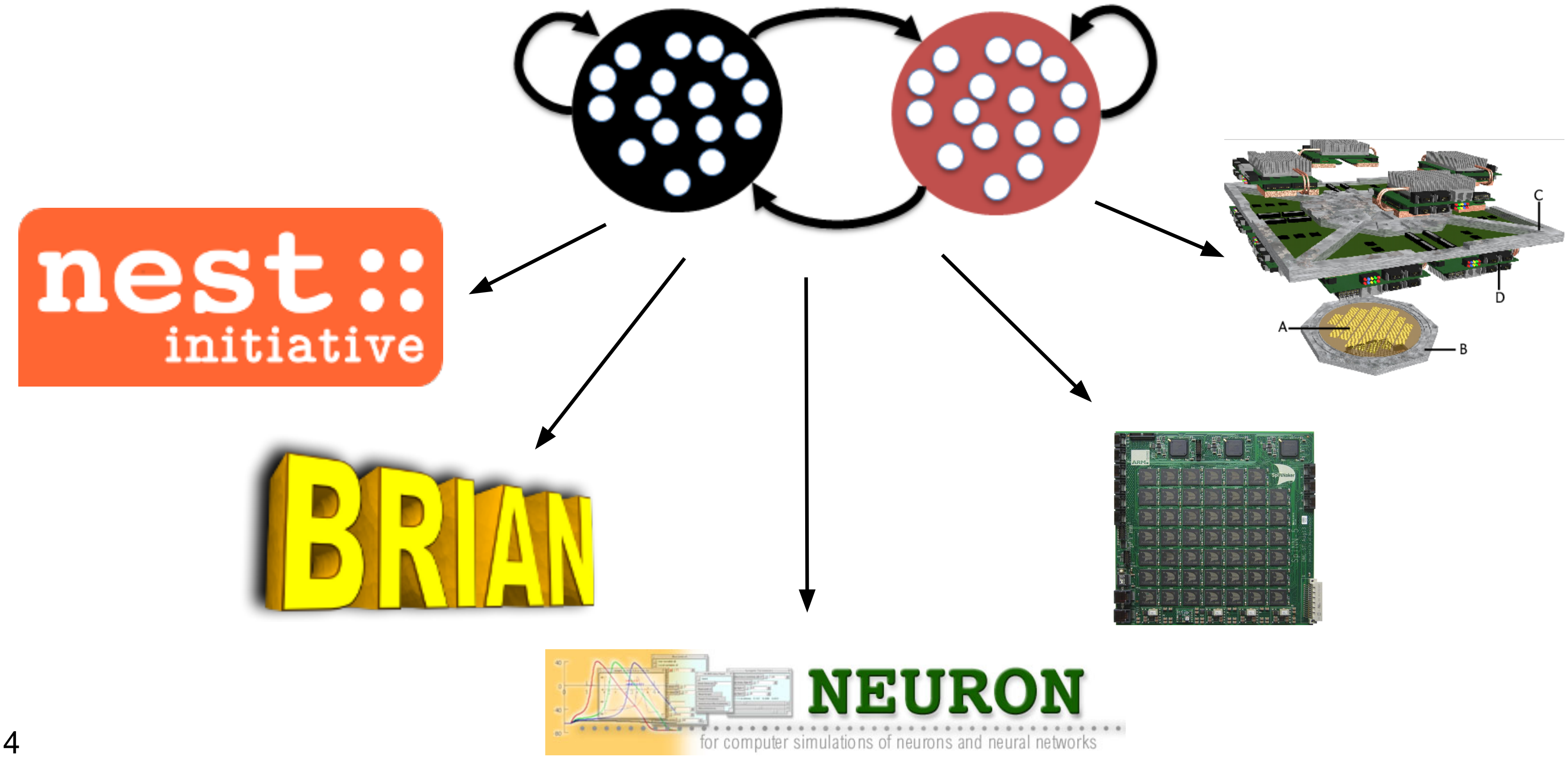
Spiking Neural Networks



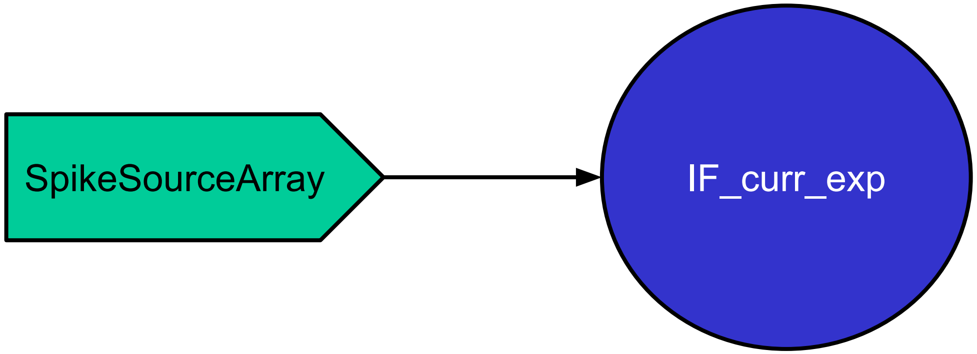
Spiking Neural Networks



What is PyNN?


nest :: initiative
BRIAN
NEURON
for computer simulations of neurons and neural networks
A
B
C
D

A Simple PyNN Network



A Simple PyNN Network

```
import pyNN.spiNNaker as p
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import pyNN.spiNNaker as p
p.setup(timestep=1.0)
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A Simple PyNN Network

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import pyNN.spiNNaker as p
p.setup(timestep=1.0)
pop_1 = p.Population(1, p.IF_curr_exp, {}, label=“pop_1”)
```
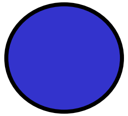
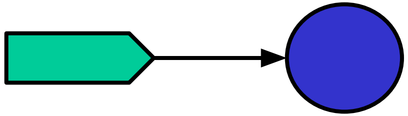



A Simple PyNN Network

```
import pyNN.spiNNaker as p
p.setup(timestep=1.0)
pop_1 = p.Population(1, p.IF_curr_exp, {}, label="pop_1")
input = p.Population(1, p.SpikeSourceArray,
                     {'spike_times': [0]}, label="input")
```

A Simple PyNN Network

```
import pyNN.spiNNaker as p
p.setup(timestep=1.0)
pop_1 = p.Population(1, p.IF_curr_exp, {}, label="pop_1")
input = p.Population(1, p.SpikeSourceArray,
                     {'spike_times': [0]}, label="input")
input_proj = p.Projection(input, pop_1, p.OneToOneConnector(
    weights=5.0, delays=1))
```



A Simple PyNN Network

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p.setup(timestep=1.0)
pop_1 = p.Population(1, p.IF_curr_exp, {}, label="pop_1")
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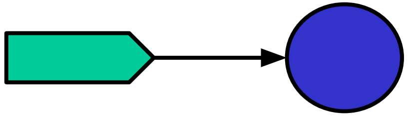
                     {'spike_times': [0]}, label="input")
input_proj = p.Projection(input, pop_1, p.OneToOneConnector(
    weights=5.0, delays=1))
pop_1.record()
pop_1.record_v()
```



A Simple PyNN Network

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pop_1 = p.Population(1, p.IF_curr_exp, {}, label="pop_1")
input = p.Population(1, p.SpikeSourceArray,
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input_proj = p.Projection(input, pop_1, p.OneToOneConnector(
    weights=5.0, delays=1))
pop_1.record()
pop_1.record_v()
p.run(10)
```
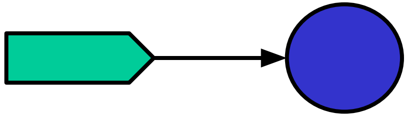



Edit ~/.spynnaker.cfg

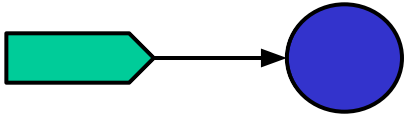
```
[Machine]
#-------
# Information about the target SpiNNaker board or machine:
# machineName:     The name or IP address of the target board
# version:         Version of the Spinnaker Hardware Board (1-5)
# machineTimeStep: Internal time step in simulations in usecs.
# timeScaleFactor: Change this to slow down the simulation time
#                      relative to real time.
#-------
machineName     = None
version         = None
#machineTimeStep = 1000
#timeScaleFactor = 1
```

Edit ~/.spynnaker.cfg

```
[Machine]
#-------
# Information about the target SpiNNaker board or machine:
# machineName:     The name or IP address of the target board
# version:         Version of the Spinnaker Hardware Board (1-5)
# machineTimeStep: Internal time step in simulations in usecs.
# timeScaleFactor: Change this to slow down the simulation time
#                      relative to real time.
#-------
machineName     = 192.168.240.253
version         = 3
#machineTimeStep = 1000
#timeScaleFactor = 1
```

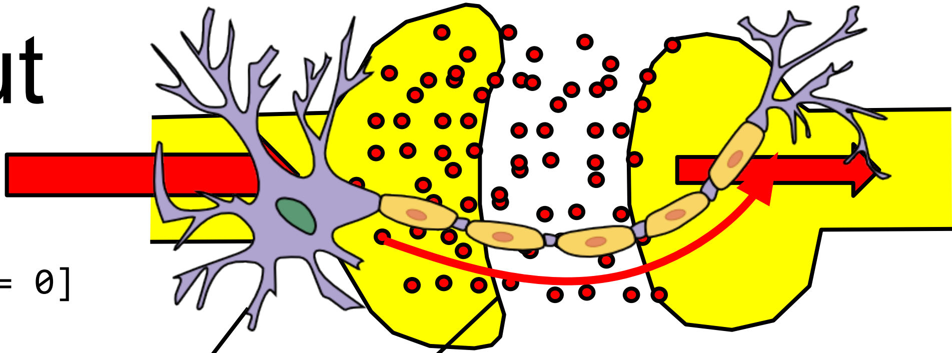
A Simple PyNN Network

```
import pyNN.spiNNaker as p
p.setup(timestep=1.0)
pop_1 = p.Population(1, p.IF_curr_exp, {}, label="pop_1")
input = p.Population(1, p.SpikeSourceArray,
                     {'spike_times': [0]}, label="input")
input_proj = p.Projection(input, pop_1, p.OneToOneConnector(
    weights=5.0, delays=1))
pop_1.record()
pop_1.record_v()
p.run(10)
spikes = pop_1.getSpikes()
v = pop_1.get_v()
```

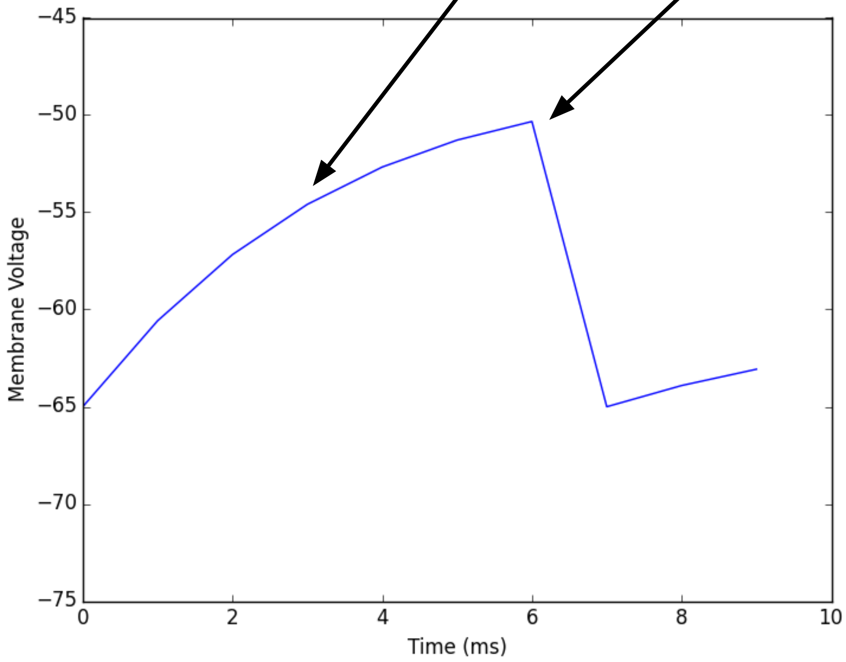


MANCHESTER 1824

Plotting Output

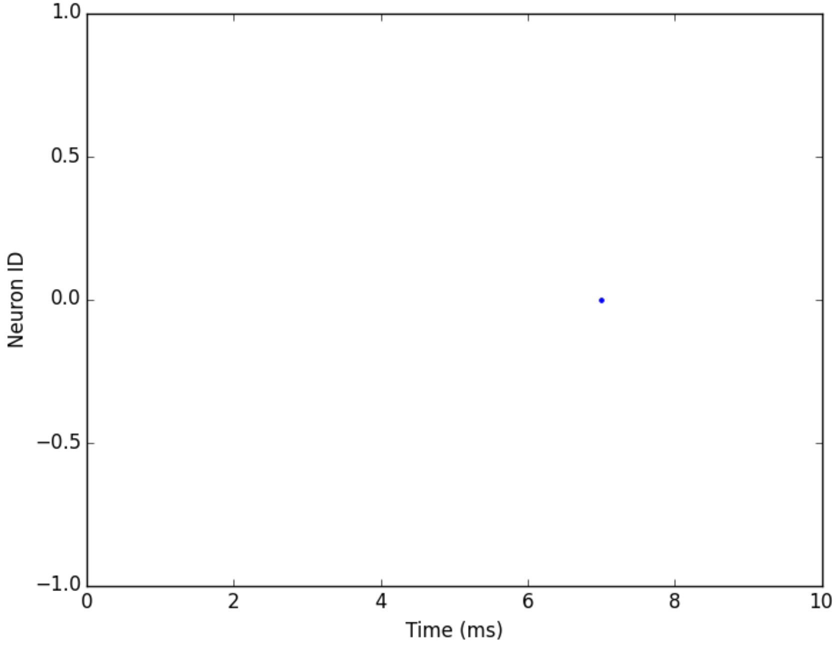


```
import pylab
time = [i[1] for i in v if i[0] == 0]
membrane_voltage = [i[2] for i in v if i[0] == 0]
pylab.plot(time, membrane_voltage)
pylab.xlabel("Time (ms)")
pylab.ylabel("Membrane Voltage")
pylab.axis([0, 10, -75, -45])
pylab.show()
```

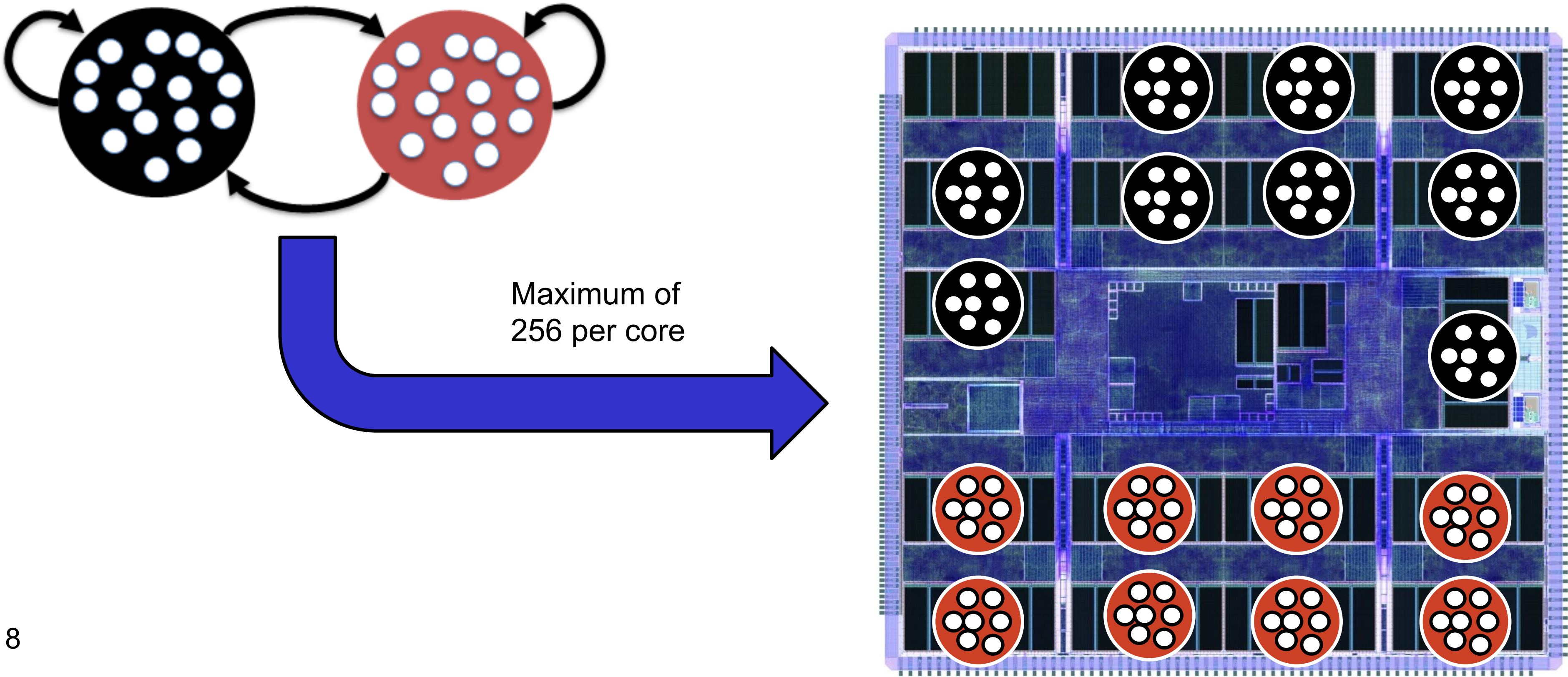


Plotting Output

```
import pylab
spike_time = [i[1] for i in spikes]
spike_id = [i[0] for i in spikes]
pylab.plot(spike_time, spike_id, ".")
pylab.xlabel("Time (ms)")
pylab.ylabel("Neuron ID")
pylab.axis([0, 10, -1, 1])
pylab.show()
```

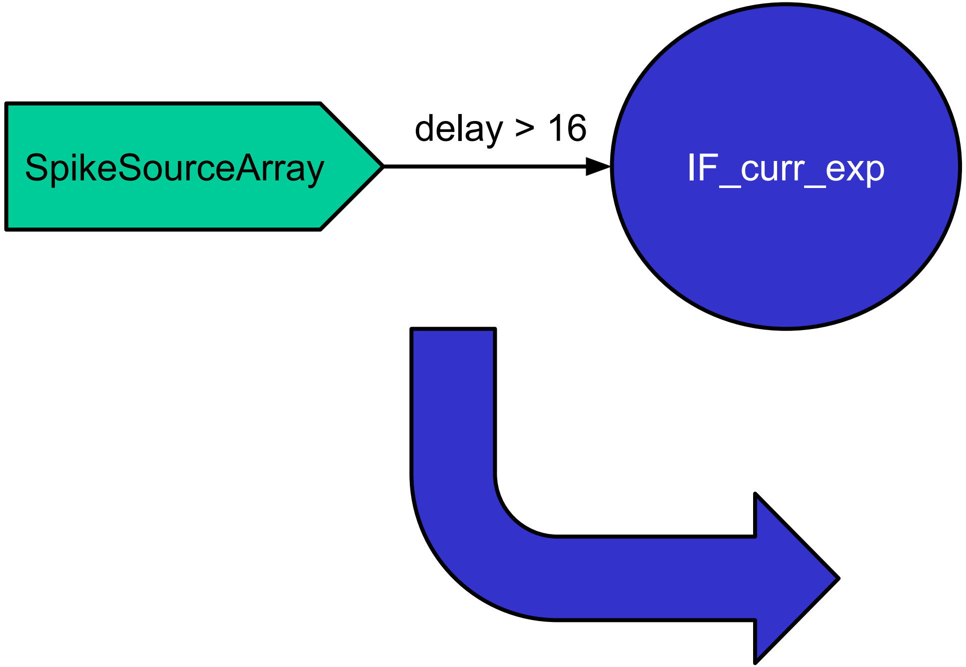


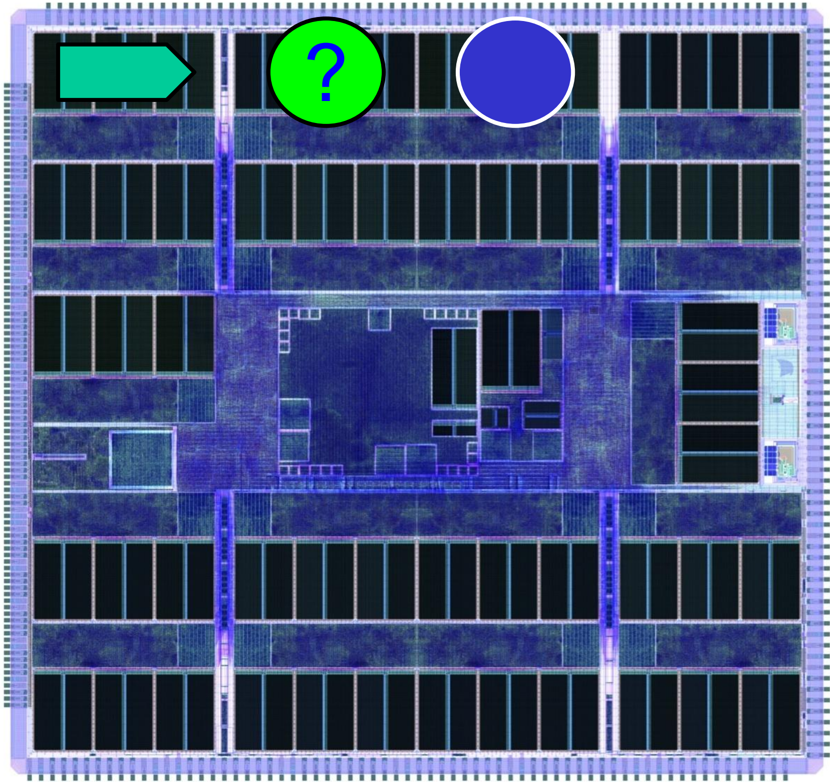
Limitations of PyNN on SpiNNaker:
Neurons Per Core



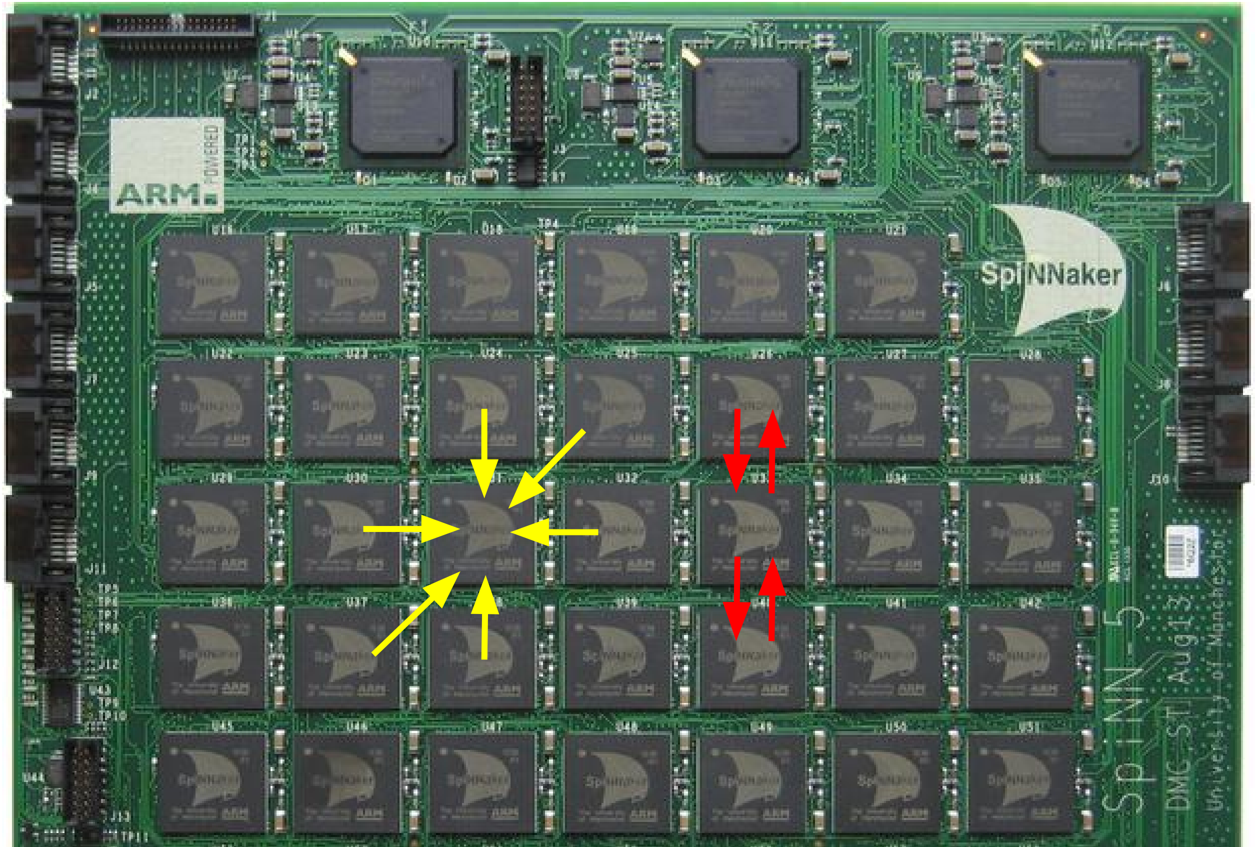
Limitations of PyNN on SpiNNaker:

Number of cores available



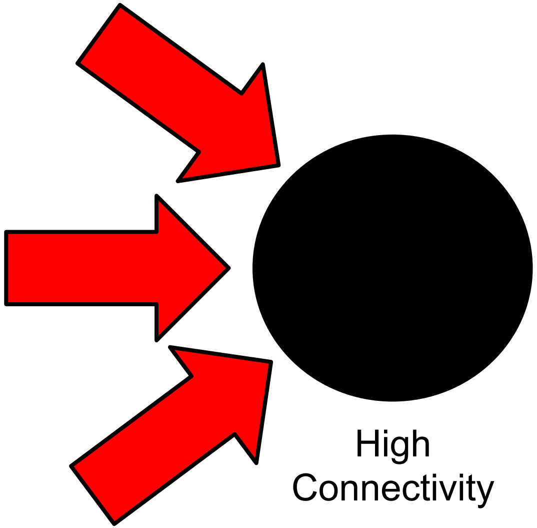


Limitations of PyNN on SpiNNaker:
Dropped Packets (Missing Spikes)

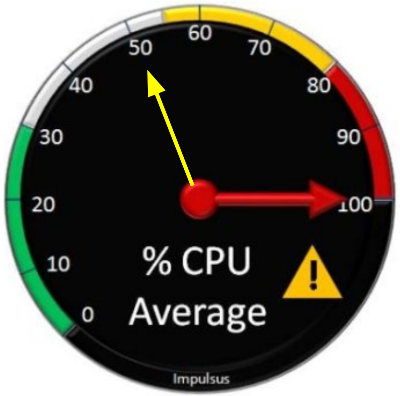


SpiNNaker-Specific PyNN

```
import pyNN.spiNNaker as p
p.setup(timestep=1.0)
p.set_number_of_neurons_per_core(p.IF_curr_exp, 100)
pop_1 = p.Population(1, p.IF_curr_exp, {}, label="pop_1")
```



High Connectivity



Plasticity

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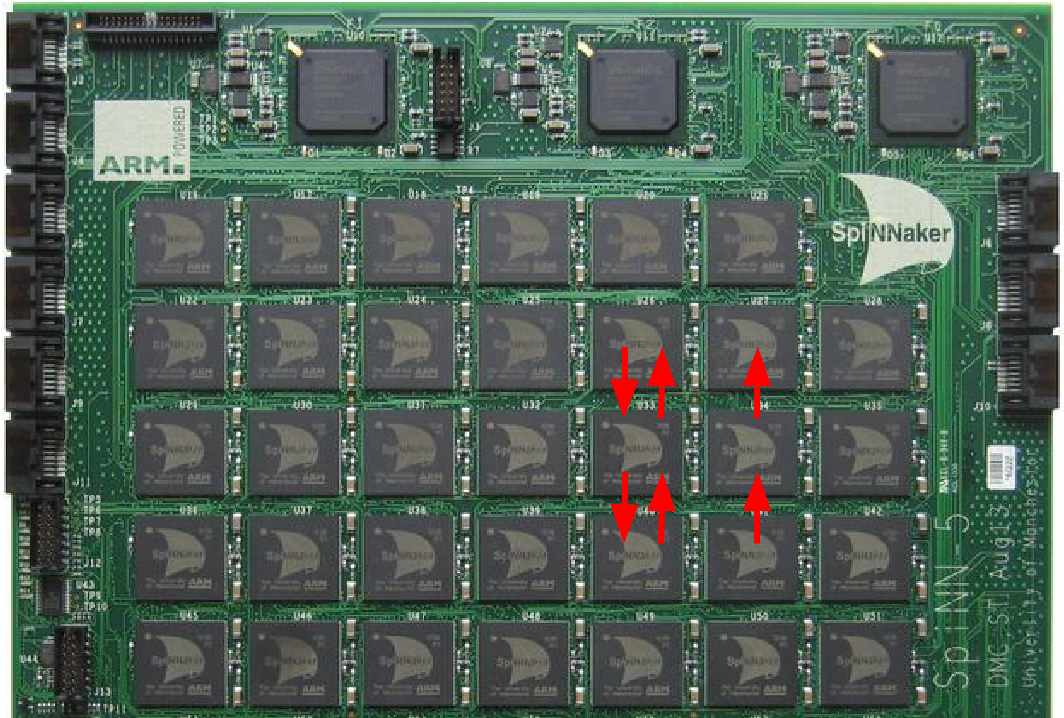
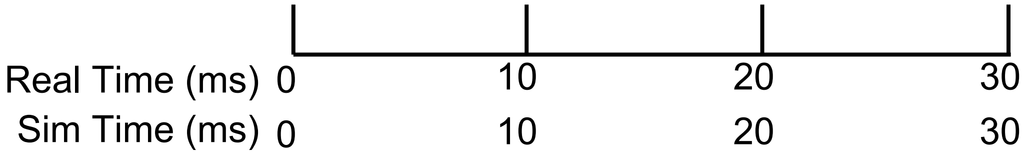
SpiNNaker-Specific PyNN

```
import pyNN.spiNNaker as p
p.setup(timestep=1.0)
pop_1 = p.Population(1, p.IF_curr_exp, {}, label=“pop_1”)
pop_1.add_placement_constraint(x=1, y=1)
```



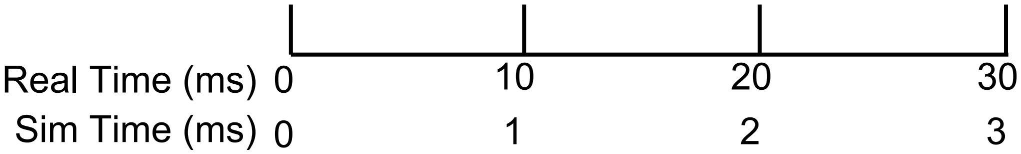
Configuration with spynnaker.cfg

```
[Machine]
machineName       = None
version           = None
timeScaleFactor   = 1
```

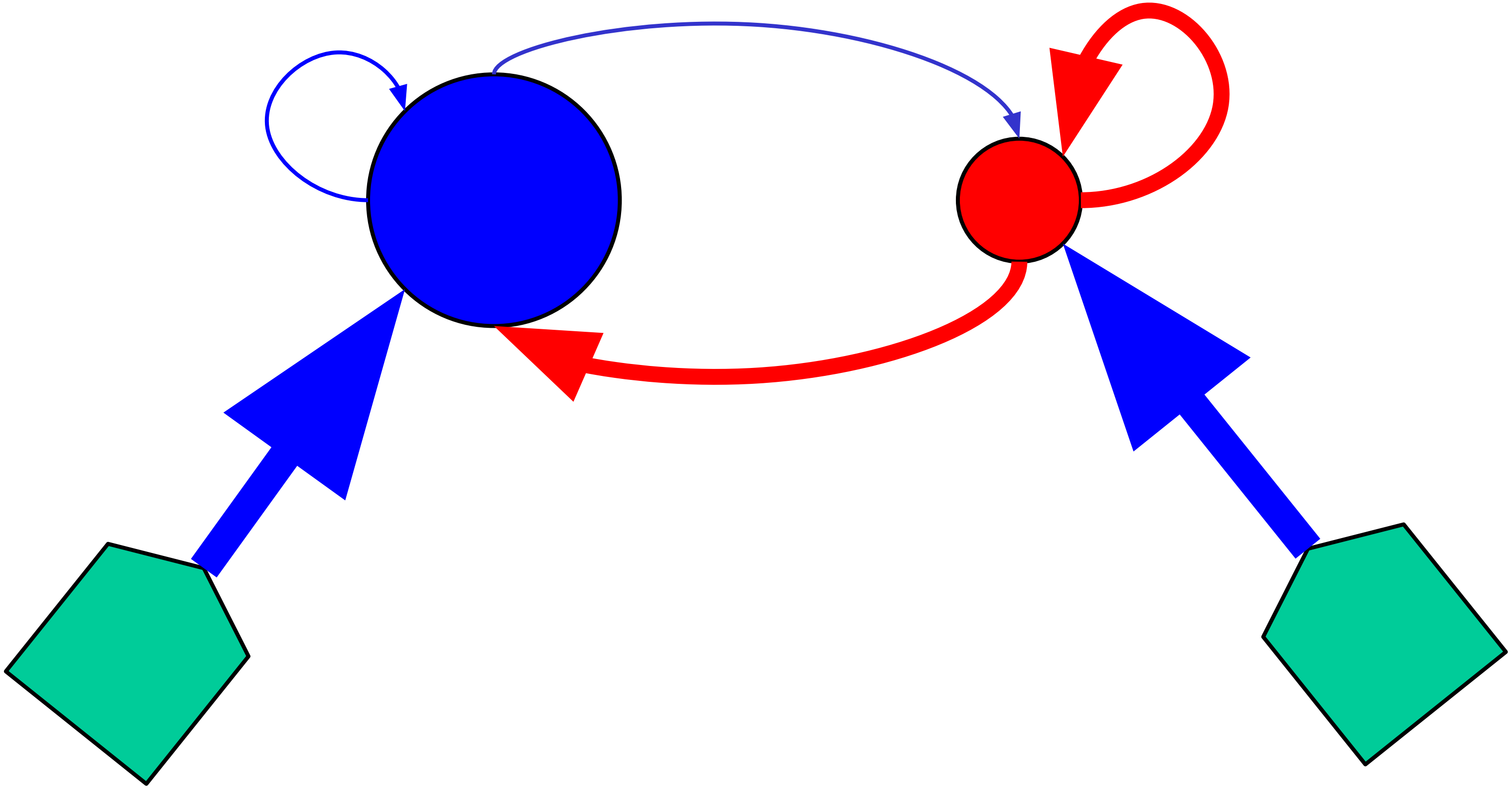


Configuration with spynnaker.cfg

```
[Machine]
machineName       = None
version           = None
timeScaleFactor   = 10
```



Balanced Random Network



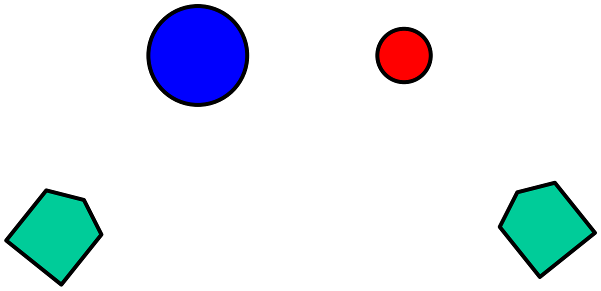
Balanced Random Network

```
import pyNN.spiNNaker as p
import pylab
from pyNN.random import RandomDistribution

p.setup(timestep=0.1)
n_neurons = 1000
n_exc = int(round(n_neurons * 0.8))
n_inh = int(round(n_neurons * 0.2))
```

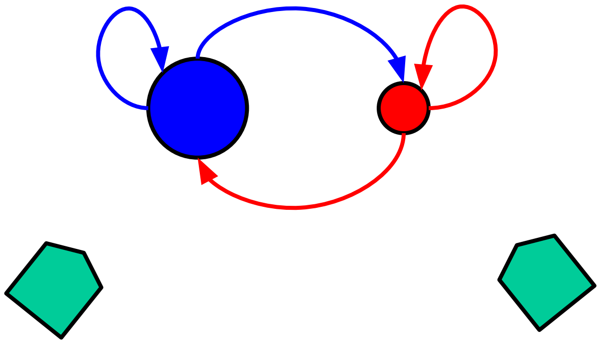
Balanced Random Network

```
pop_exc = p.Population(n_exc, p.IF_curr_exp, {},
                       label="Excitatory")
pop_inh = p.Population(n_inh, p.IF_curr_exp, {},
                       label="Inhibitory")
stim_exc = p.Population(n_exc, p.SpikeSourcePoisson,
                        {"rate": 10.0}, label="Stim_Exc")
stim_inh = p.Population(n_inh, p.SpikeSourcePoisson,
                        {"rate": 10.0}, label="Stim_Inh")
```



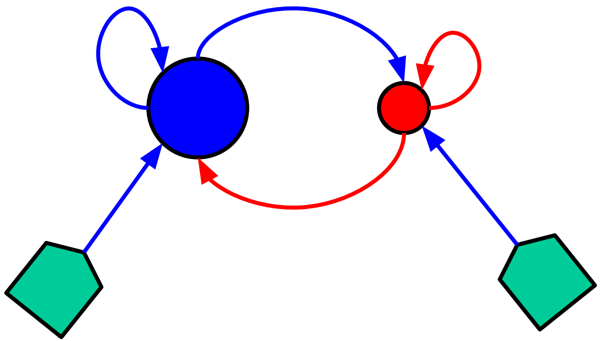
Balanced Random Network

```
conn_exc = p.FixedProbabilityConnector(0.1, weights=0.2,
                                        delays=2.0)
conn_inh = p.FixedProbabilityConnector(0.1, weights=-1.0,
                                        delays=2.0)
p.Projection(pop_exc, pop_exc, conn_exc, target="excitatory")
p.Projection(pop_exc, pop_inh, conn_exc, target="excitatory")
p.Projection(pop_inh, pop_inh, conn_inh, target="inhibitory")
p.Projection(pop_inh, pop_exc, conn_inh, target="inhibitory")
```



Balanced Random Network

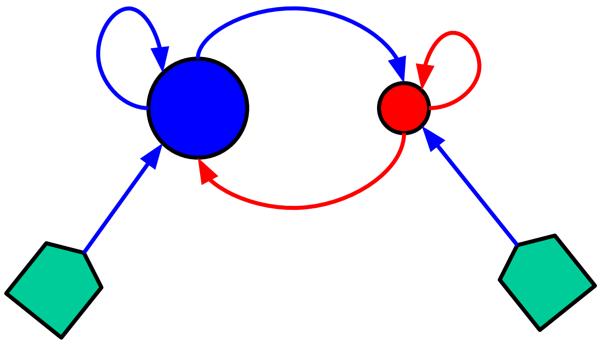
```
delays_stim = RandomDistribution("uniform", [1.0, 1.6])
conn_stim = p.OneToOneConnector(weights=2.0,
                                delays=delays_stim)
p.Projection(stim_exc, pop_exc, conn_stim, target="excitatory")
p.Projection(stim_inh, pop_inh, conn_stim, target="excitatory")
```



Balanced Random Network

```
pop_exc.initialize("v", RandomDistribution("uniform",
                                           [-65.0, -55.0]))
pop_inh.initialize("v", RandomDistribution("uniform",
                                           [-65.0, -55.0]))

pop_exc.record()
p.run(1000)
```



Balanced Random Network

```
spikes = pop_exc.getSpikes()
pylab.plot([i[1] for i in spikes], [i[0] for i in spikes], ".")
pylab.xlabel("Time (ms)")
pylab.ylabel("Neuron ID")
pylab.axis([0, 1000, -1, n_exc + 1])
pylab.show()
```