In [1]:
```
import matplotlib
import os
import json
# !pip install neuron
# !pip install netpyne
```

In [2]:
```
%matplotlib inline
```

In [3]:
```
!nrnivmodl
```

```
/usr/bin/xcrun
/Users/sherryzhou/Desktop/netpyne2022/netpyne/netpyne/tts/nc2021
Mod files: "./ichanR859C1.mod" "./ichanWT2005.mod" "./izhi2007b.mod"

 -> Compiling mod_func.cpp
 => LINKING shared library ./libnrnmech.dylib
Successfully created x86_64/special
```

In [4]:
```
if os.path.isdir('/content/cells_netpyne2021'):
  !rm -r /content/cells_netpyne2021
```

In [5]:
```
###### Stimulation Code
### 4 populations
from netpyne import specs, sim
netParams = specs.NetParams()
simConfig = specs.SimConfig()
```

In [6]:
```
# Pyramidal - cortical
PYRcell = {'secs': {}}
PYRcell['secs']['soma'] = {'geom': {}, 'mechs': {}}
PYRcell['secs']['soma']['geom'] = {'diam': 18.8, 'L': 18.8, 'Ra': 123.0}
PYRcell['secs']['soma']['mechs']['hh'] = {'gnabar': 0.12, 'gkbar': 0.036, 'gl':
PYRcell['secs']['soma']['vinit'] = -100 # initial membrane potential
netParams.cellParams['PYR'] = PYRcell
```

In [7]:
```
# Inhibitory - cortical
Icell = {'secs': {}}
Icell['secs']['soma'] = {'geom': {}, 'mechs': {}}
Icell['secs']['soma']['geom'] = {'diam': 10.0, 'L': 9.0, 'Ra': 110.0}
Icell['secs']['soma']['mechs']['hh'] = {'gnabar': 0.12, 'gkbar': 0.036, 'gl': 0.
netParams.cellParams['I'] = Icell
```

In [8]:
```
# Reticular nucleus - thalamic
REcell = {'secs': {}}
REcell['secs']['soma'] = {'geom': {}, 'mechs': {}}
REcell['secs']['soma']['geom'] = {'diam': 18.8, 'L': 18.8, 'Ra': 123.0}
REcell['secs']['soma']['mechs']['hh'] = {'gnabar': 0.12, 'gkbar': 0.036, 'gl': 0
REcell['secs']['dend'] = {'geom': {}, 'topol': {}, 'mechs': {}}
REcell['secs']['dend']['geom'] = {'diam': 5.0, 'L': 150.0, 'Ra': 150.0, 'cm': 1}
REcell['secs']['dend']['topol'] = {'parentSec': 'soma', 'parentX': 0, 'childX':
```

```
REcell['secs']['dend']['mechs']['pas'] = {'g': 0.0000357, 'e': -70}
netParams.cellParams['RE'] = REcell
```

In [9]:

```
# # Thalamocortical - thalamic
TCcell = {'secs': {}}
TCcell['secs']['soma'] = {'geom': {}, 'topol': {}, 'mechs': {}}
TCcell['secs']['soma']['geom'] = {'diam': 18.8, 'L': 18.8, 'Ra': 123.0}
TCcell['secs']['soma']['mechs']['hh'] = {'gnabar': 0.12, 'gkbar': 0.036, 'gl': 0
TCcell['secs']['dend'] = {'geom': {}, 'mechs': {}}
TCcell['secs']['dend']['geom'] = {'diam': 18.8, 'L': 18.8, 'Ra': 123.0}
TCcell['secs']['dend']['topol'] = {'parentSec': 'soma', 'parentX': 0, 'childX':
TCcell['secs']['dend']['mechs']['pas'] = {'g': 0.0000357, 'e': -70}
netParams.cellParams['TC'] = TCcell
```

In [10]:

```
netParams.popParams['PY'] = {'cellType': 'PYR', 'numCells': 120}
netParams.popParams['IN'] = {'cellType': 'I', 'numCells': 120}
netParams.popParams['RE'] = {'cellType': 'RE', 'numCells': 120}
netParams.popParams['TC'] = {'cellType': 'TC', 'numCells': 120}
```

In [11]:

```
netParams.synMechParams['AMPA'] = {'mod': 'Exp2Syn', 'tau1': 0.1, 'tau2': 1.0, '
netParams.synMechParams['GABAA'] = {'mod': 'Exp2Syn', 'tau1': 0.3, 'tau2': 4.25,
netParams.synMechParams['GABAB'] = {'mod': 'Exp2Syn', 'tau1': 0.1, 'tau2': 10, '
```

In [12]:

```
netParams.stimSourceParams['bkg'] = {'type': 'NetStim', 'rate': 1, 'noise': 1, '
netParams.stimTargetParams['bkg->PYR1'] = {'source': 'bkg', 'conds': {'pop': ['P
```

In [13]:

```
netParams.connParams['PY->IN'] = {
        'preConds': {'pop': 'PY'},
        'postConds': {'pop': 'IN'},
        'sec': 'dend',
        'synMech': 'AMPA',
        'weight': 0.1,
        'delay': 5,
        'probability': 0.25}

netParams.connParams['PY->PY'] = {
        'preConds': {'pop': 'PY'},
        'postConds': {'pop': 'PY'},
        'sec': 'dend',
        'synMech': 'AMPA',
        'weight': 0.1,
        'delay': 5,
        'probability': 0.25}

netParams.connParams['PY->RE'] = {
        'preConds': {'pop': 'PY'},
        'postConds': {'pop': 'RE'},
        'sec': 'dend',
        'synMech': 'AMPA',
        'weight': 0.1,
        'delay': 5,
        'probability': 0.25}

netParams.connParams['PY->TC'] = {
```

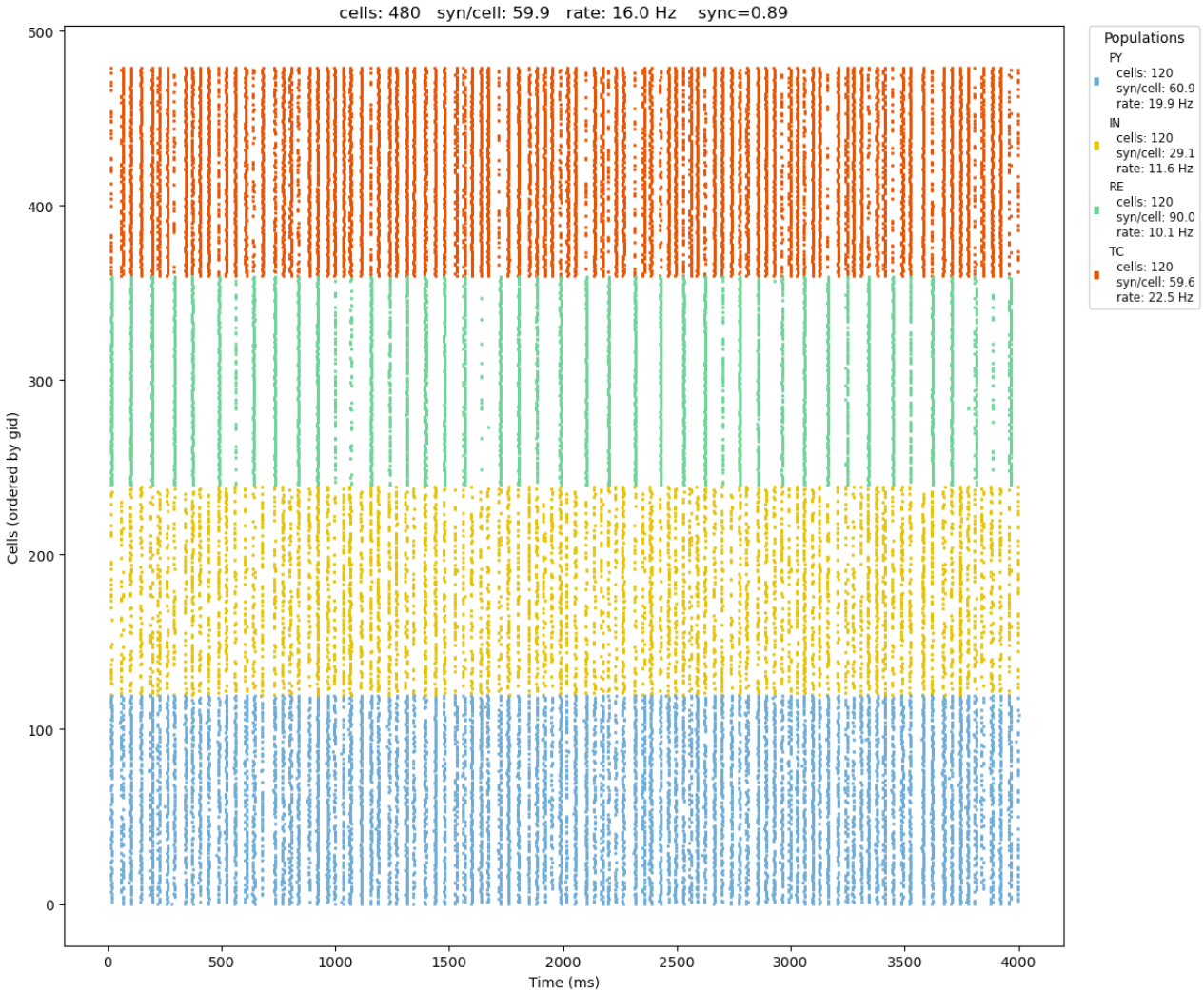
```
        'preConds': {'pop': 'PY'},
        'postConds': {'pop': 'TC'},
        'sec': 'dend',
        'synMech': 'AMPA',
        'weight': 0.1,
        'delay': 5,
        'probability': 0.25}

netParams.connParams['RE->TC'] = {
        'preConds': {'pop': 'RE'},
        'postConds': {'pop': 'TC'},
        'sec': 'dend',
        'synMech': 'GABAA',
        'weight': 0.1,
        'delay': 5,
        'probability': 0.25}

netParams.connParams['RE->RE'] = {
        'preConds': {'pop': 'RE'},
        'postConds': {'pop': 'RE'},
        'sec': 'dend',
        'synMech': 'GABAB',
        'weight': 0.1,
        'delay': 5,
        'probability': 0.25}

netParams.connParams['TC->RE'] = {
        'preConds': {'pop': 'TC'},
        'postConds': {'pop': 'RE'},
        'sec': 'dend',
        'synMech': 'AMPA',
        'weight': 0.1,
        'delay': 5,
        'probability': 0.25}

netParams.connParams['TC->PY'] = {
        'preConds': {'pop': 'TC'},
        'postConds': {'pop': 'PY'},
        'sec': 'dend',
        'synMech': 'AMPA',
        'weight': 0.1,
        'delay': 5,
        'probability': 0.25}
```

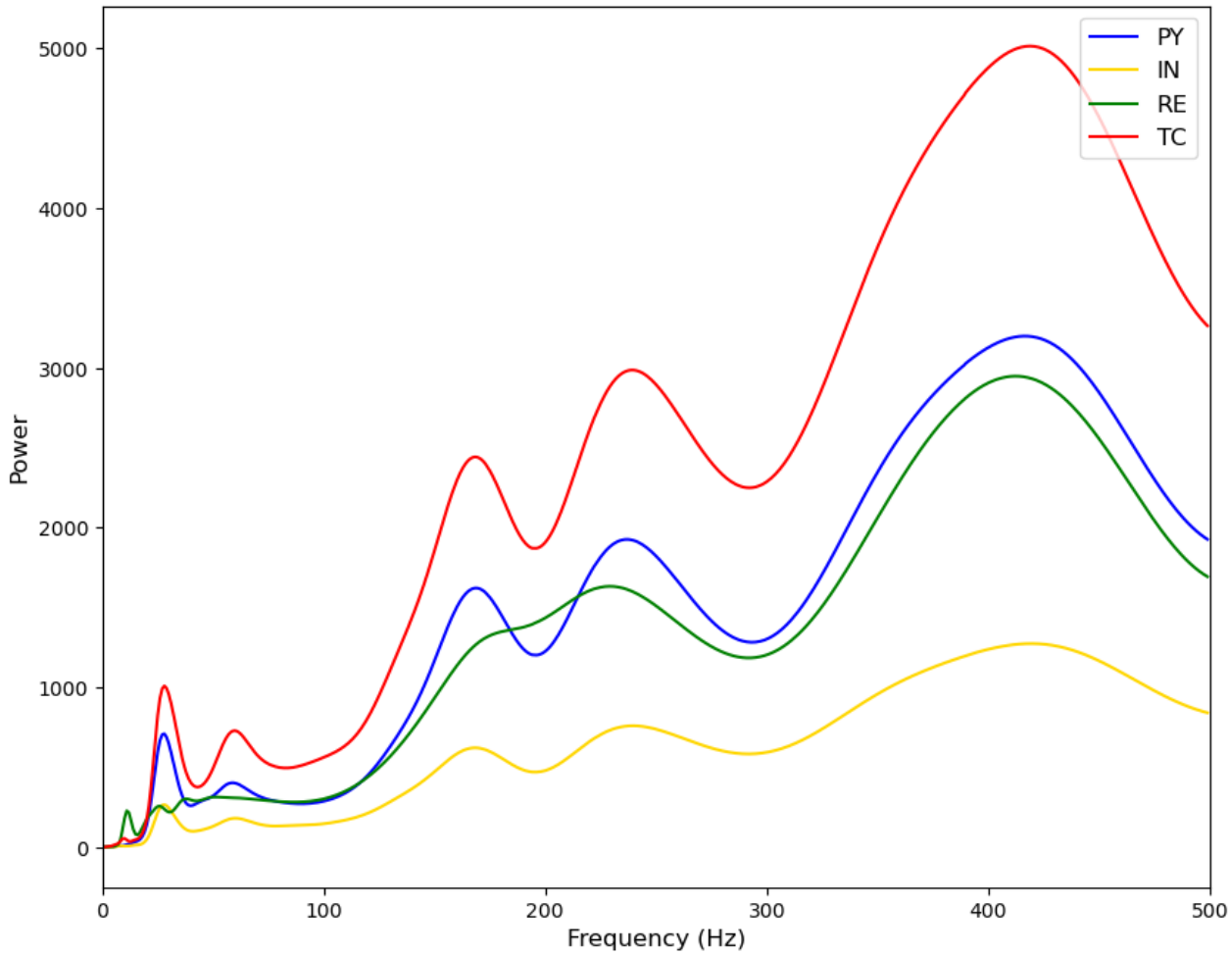
In [14]:

```
simConfig.duration = 4*1e3
simConfig.dt = 0.025
simConfig.seeds = {'conn': 1, 'stim': 1, 'loc': 1}
simConfig.verbose = False
simConfig.hParams = {'v_init': PYRcell['secs']['soma']['vinit']}

# Recording
simConfig.recordCells = []
simConfig.recordTraces = {'Vsoma': {'sec': 'soma','loc': 0.5,'var': 'v'}}
simConfig.recordStim = True
simConfig.recordStep = 0.1

# Saving
simConfig.filename = 'HHTut'
simConfig.saveFileStep = 1000
```

```
simConfig.savePickle = False
simConfig.saveJson = True

# Analysis and plotting
simConfig.analysis['plotRaster'] = {'saveData': 'raster_data.json', 'saveFig': T
simConfig.analysis['plotRatePSD'] = {'include': ['PY', 'IN', 'RE', 'TC'],'maxFre
# simConfig.analysis['plotTraces'] = {'include': [2], 'saveFig': True, 'showFig'
# simConfig.analysis ['plot2Dnet'] = {'saveData': True,'saveFig': True, 'showFig
sim.createSimulateAnalyze(netParams = netParams, simConfig = simConfig)
```

```
Start time:  2022-12-11 23:42:17.873074

Creating network of 4 cell populations on 1 hosts...
  Number of cells on node 0: 480
  Done; cell creation time = 0.07 s.
Making connections...
  Number of connections on node 0: 28623
  Done; cell connection time = 1.70 s.
Adding stims...
  Number of stims on node 0: 120
  Done; cell stims creation time = 0.01 s.
Recording 480 traces of 1 types on node 0

Running simulation using NEURON for 4000.0 ms...
  Done; run time = 110.81 s; real-time ratio: 0.04.

Gathering data...
  Done; gather time = 0.73 s.

Analyzing...
  Cells: 480
  Connections: 28743 (59.88 per cell)
  Spikes: 30803 (16.04 Hz)
  Simulated time: 4.0 s; 1 workers
  Run time: 110.81 s
Saving output as HHTut_data.json ...
Finished saving!
  Done; saving time = 0.73 s.
Preparing spike data...
Saving data as HHTut_spike_data.pkl ...
Plotting raster...
Saving data as HHTut_data.pkl ...
Plotting firing rate power spectral density (PSD) ...
```


cells: 480 syn/cell: 59.9 rate: 16.0 Hz sync=0.89
Cells (ordered by gid)
Time (ms)
0
100
200
300
400
500
0
500
1000
1500
2000
2500
3000
3500
4000
Populations
PY
cells: 120
syn/cell: 60.9
rate: 19.9 Hz
IN
cells: 120
syn/cell: 29.1
rate: 11.6 Hz
RE
cells: 120
syn/cell: 90.0
rate: 10.1 Hz
TC
cells: 120
syn/cell: 59.6
rate: 22.5 Hz




```
Done; plotting time = 1.80 s

Total time = 115.87 s
```

In [ ]:

In [ ]: