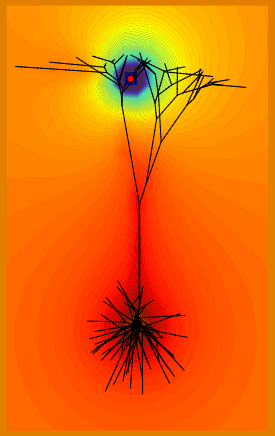

LFPy

Local Field Potentials in Python

LFPy-tutorial CNS2013

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LFPy - Introduction

- **LFPy** is a **Python**-package for calculating extracellular potentials from multi-compartment neuron models
- **LFPy** home page: http://compneuro.umb.no/LFPy
- Live LFPyLubuntu image: http://goo.gl/1sOiM
  - Use .iso-file with Virtualbox or similar, see http://www.virtualbox.org
  - Comes with the **Python --pylab** environment, **LFPy** and **NEURON** preinstalled

LFPy - Introduction

- Topics:
  - Why model extracellular potentials?
  - Biophysical modeling scheme (brief)
  - LFPy overview
  - LFPy installation
  - Brief explanation of the main classes in LFPy
  - LFPy usage
  - LFPy provided examples

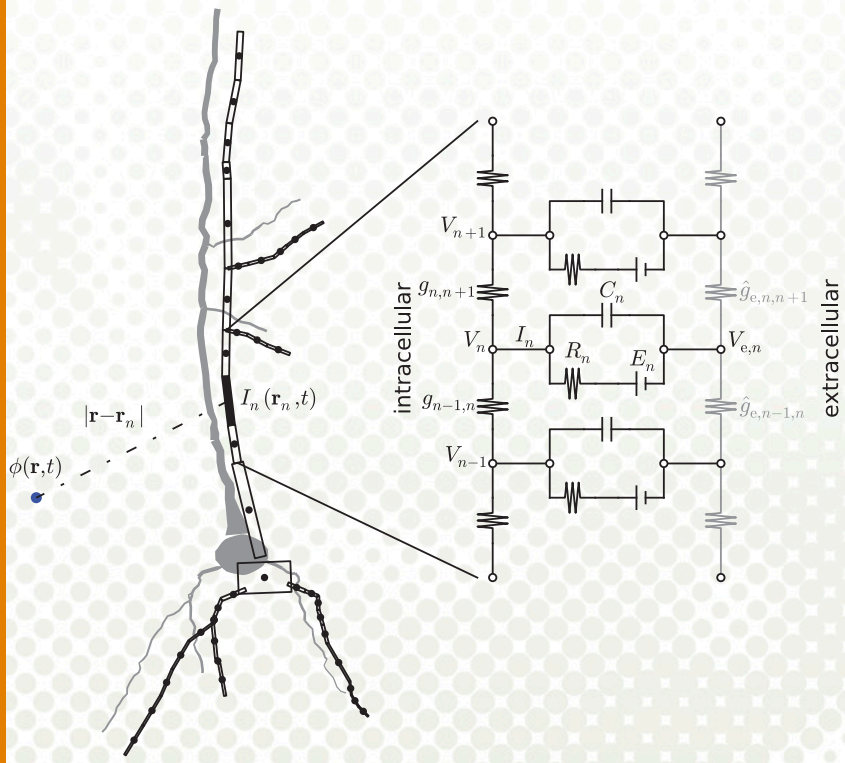
LFPy - Introduction

- Why model extracellular potentials?
  - Improve understanding of experimental measurements:
    - Reach of LFP (Łęski et al. *PLoS Comp Biol*, 2013; Lindén et al. *Neuron*, 2011)
    - Spectral content of LFP (Lindén et al. *J Comput* Neurosci, 2010)
    - Extracellular action potential shapes (Gold et al. J *Neurophysiol*, 2006; Pettersen et al. *Biophys J*, 2008)
  - Methods validation:
    - Spike sorting (Einevoll et al. *Curr Op Neurobiol*, 2012)
    - CSD estimation (Łęski et al. *Neuroinf*, 2011; Pettersen et al. *J Comput Neurosci*, 2008)

`LFPy` - Introduction

- Why model extracellular potentials?
  - **O14**: Taxidis et al.; Extracellular field signatures of CA1 spiking cell assemblies during sharp wave-ripple complexes
  - **P119**: Hagen et al.; Hybrid scheme for modeling LFPs from spiking cortical network models
  - **P120**: Ness et al.; Modeling Extracellular Potentials in Microelectrode Array Recordings
  - **P417**: Chintaluri et al.; Realistic simulations of local field potentials in a slice
  - others: **P41**, **P126**, **P255**, …

LFPy - Introduction



- Forward-modeling scheme for extracellular potentials for multi-compartment neuron models:

$$\Phi(\mathbf{r},t) = \frac{1}{4\pi\sigma_e}\sum_{n=1}^{N}\frac{I_n(t)}{|\mathbf{r}-\mathbf{r}_n|}$$

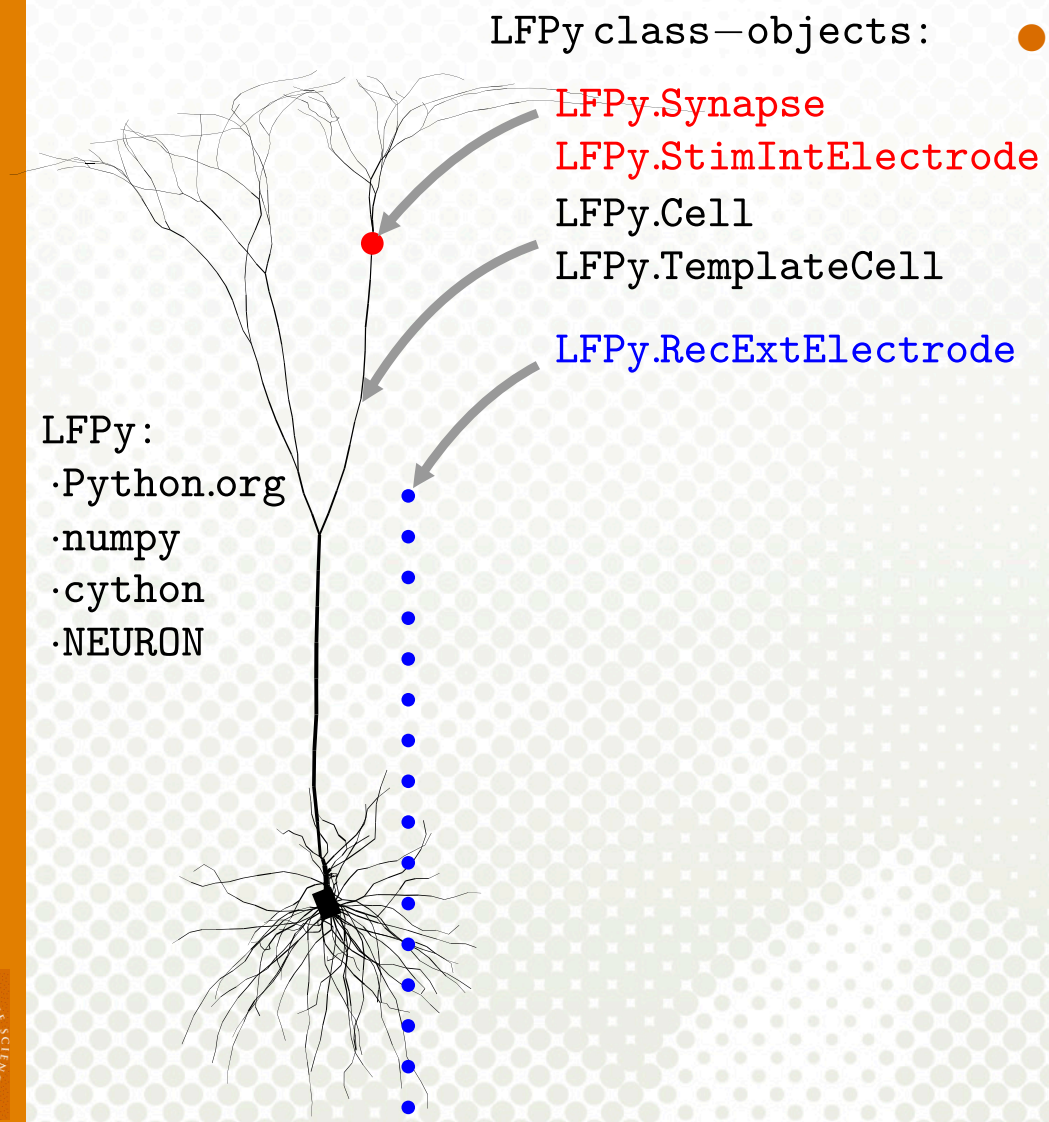
- Line-sources (Holt & Koch 1999)

$$\Phi(\mathbf{r},t) = \frac{1}{4\pi\sigma_e}\sum_{n=1}^{N} I_n(t)\int\frac{d\mathbf{r}_n}{|\mathbf{r}-\mathbf{r}_n|}$$

- Current conservation imply:

$$\sum_{n=1}^{N} I_n(t) = 0$$

LFPy - Overview



- Why **Python**?
  - Object oriented
  - Easy to script
  - Flexible
  - Plethora of packages for visualizations and analysis
  - **http://pypi.python.org/pypi**: ~32500 packages
  - Interface other programming languages

LFPy - Installation

- Make sure **Python**-prerequisites are met:
  - **neuron** (./configure --with-nrnpython)
  - **Cython, NumPy, SciPy, matplotlib** (opt. **ipython (notebook), h5py, mpi4py**)
- Download the **LFPy** source code:
  http://compneuro.umb.no/LFPy/downloads/LFPy-0.9.5.tar.gz
- Unzip:
  tar –xzf LFPy-0.9.5.tar.gz
- Or, get development version of **LFPy** using subversion:
  **svn co **
  http://bebiservice.umb.no/svn-public/LFPy-release/trunk **LFPy**

LFPy - Installation

- Install from LFPy source code:

```
cd /path/to/LFPy
python setup.py install --user
```

- Easy installation of **LFPy**:

```
easy_install LFPy --user
```

- Small test with IPython:

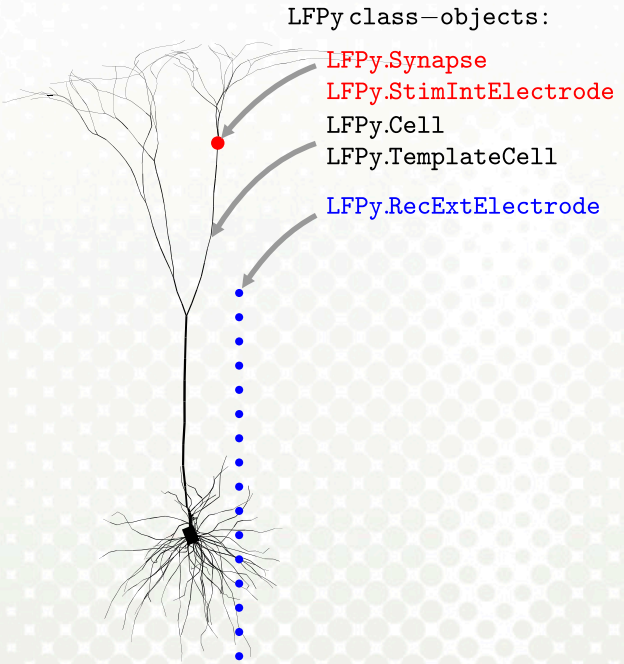
```
ipython -c "import LFPy"
NEURON -- VERSION 7.3
(694:9d4ab20927bc) 9d4ab20927bc
...
```

- With NEURON:

```
nrngui --python -c "import LPFy"
```

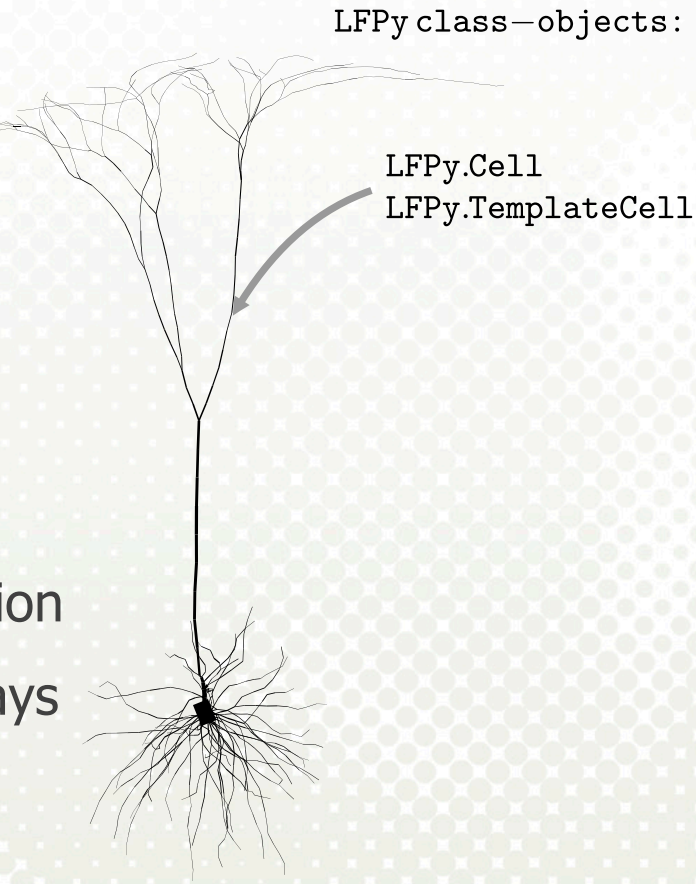
`LFPy` – Main Classes

- The primary **`LFPy`**-classes employed to set up simulations are:
  - **`LFPy.Cell`**
  - **`LFPy.Synapse`**
  - **`LFPy.RecExtElectrode`**
- Other classes and functions:
  - class **`LFPy.StimIntElectrode`**
  - functions **`LFPy.lfpcalc.calc_lfp*`**, **`LFPy.inputgenerators.*`**, **`LFPy.tools.*`**
- For detailed information please refer to the online documentation:
  `http://compneuro.umb.no/LFPy/classes.html`



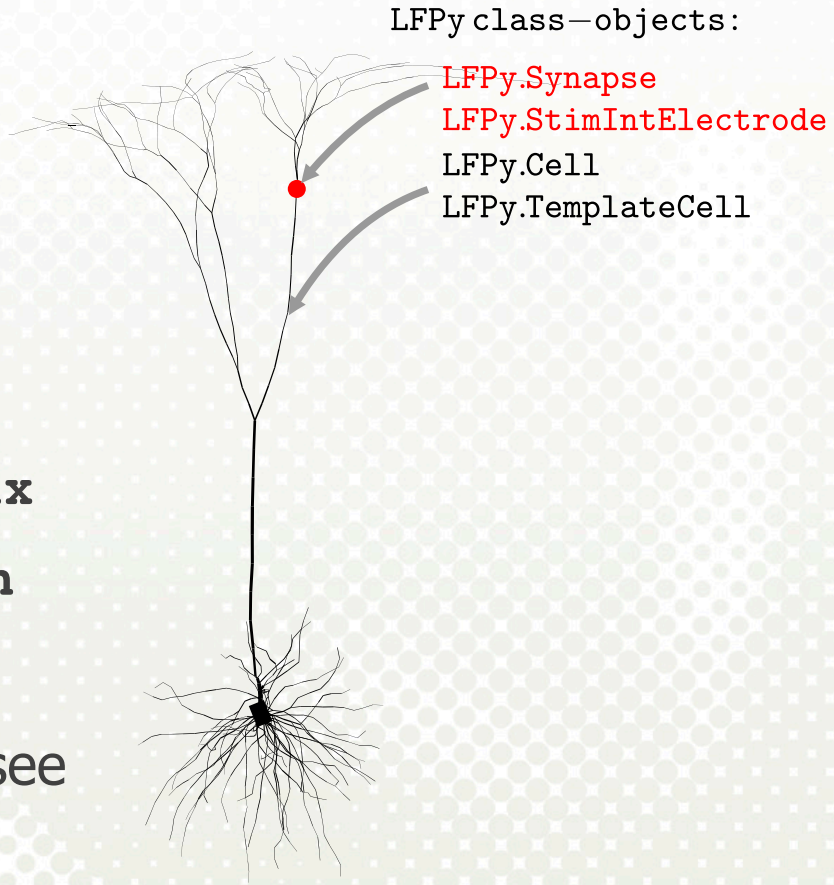
`LFPy` – Main Classes

- **`LFPy.Cell:`**
  - Uses **`NEURON`** under the hood
  - Loads the morphology
  - Set the neuronal properties:
    - membrane mechanisms
    - number of compartments
    - Set cell location and rotation
  - Collect the geometry into arrays
  - Methods for segment indices
  - positioning in 3D
  - Simulation control



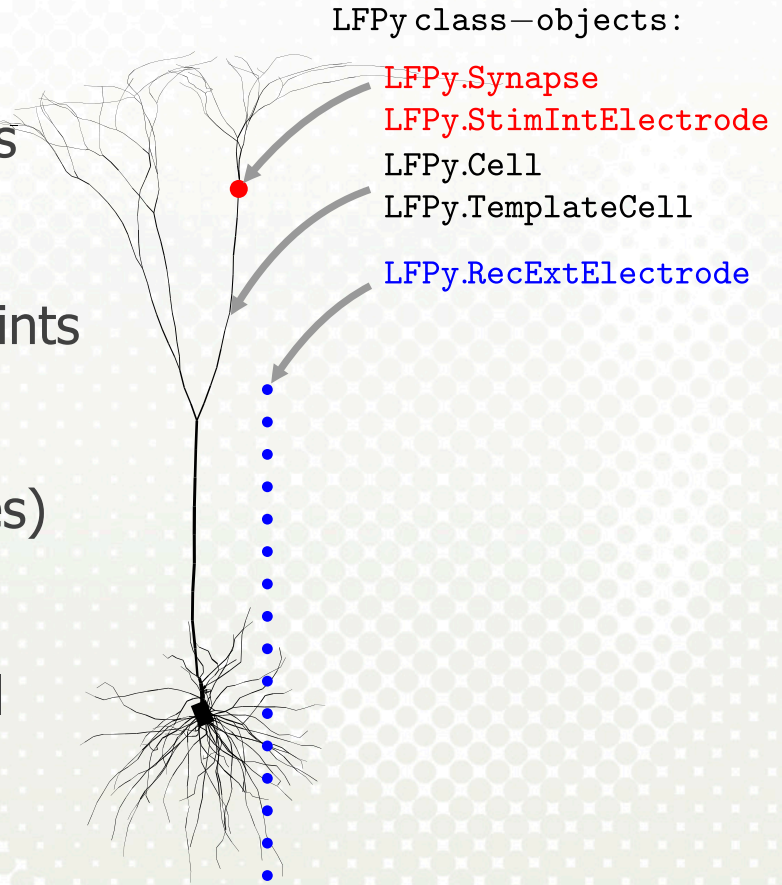
`LFPy` - Main Classes

- **`LFPy.Synapse:`**
  - attach synapse-objects onto cell objects
  - Keyword arguments:
    - **`cell`**–object
    - compartment index, **`idx`**
    - synapse type, **`Exp2syn`**
    - mechanism arguments
- Set up as **`NetCon`** objects (see **`NEURON`** documentation) for synaptic weights and times.



`LFPy` - Main Classes

- **`LFPy.RecExtElectrode`**
  - extracellular recording devices
  - Main arguments:
    - Coordinates of contact points
    - extracellular conductivity
    - method (point/line-sources)
  - Optional:
    - radius and surface normal vectors for the contacts
    - n-point surface area averaged potential

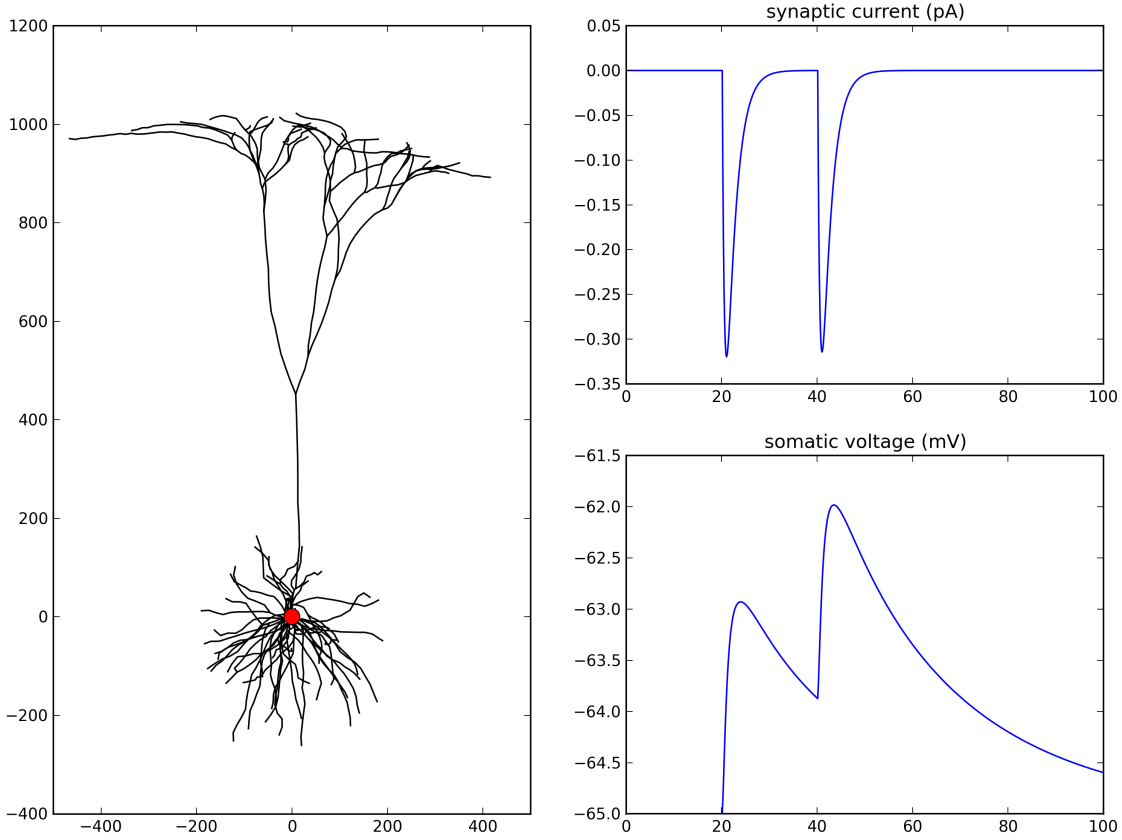


LFPy - Usage

- Working in local folder:
  `cd /path/to/LFPy/examples/`
- Have a look at the two provided **ipython** notebooks
  - Post-synaptic response of somatic synapse
  - LFPs from a single, apical synapse
- Employ an interactive ipython notesession:
  `ipython notebook --pylab inline`
- Two interactive examples should be available:

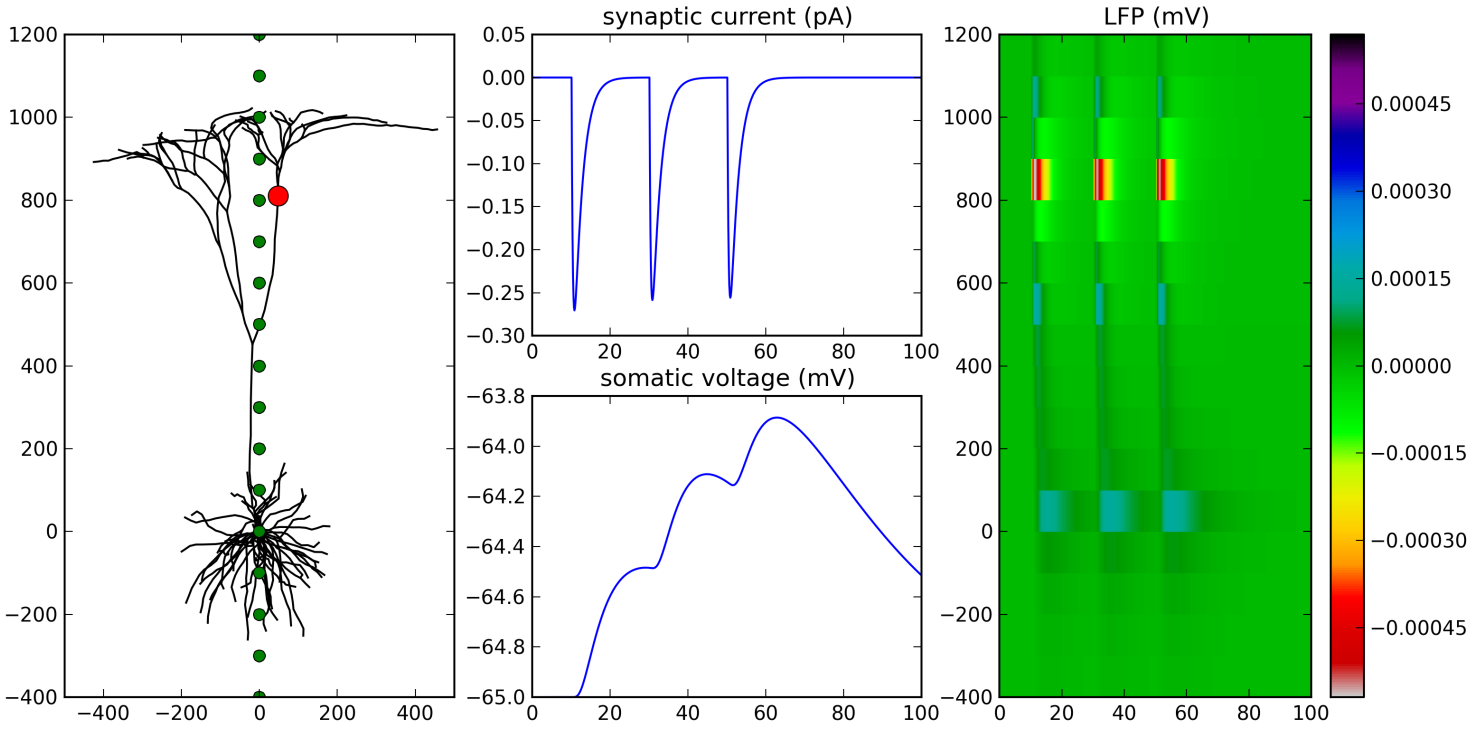
LFPy - Usage

- Interactive example 1:
  - Calculate the post-synaptic response of somatic synapse



LFPy - Usage

- Interactive example 2:
  - Calculate LFPs arising from a single, apical synapse



`LFPy` – Provided example files

- `LFPy` comes with example scripts displaying different usage cases:
  - using active cell models
  - using many synapses
  - dealing with a population of cell objects
- Example files in:

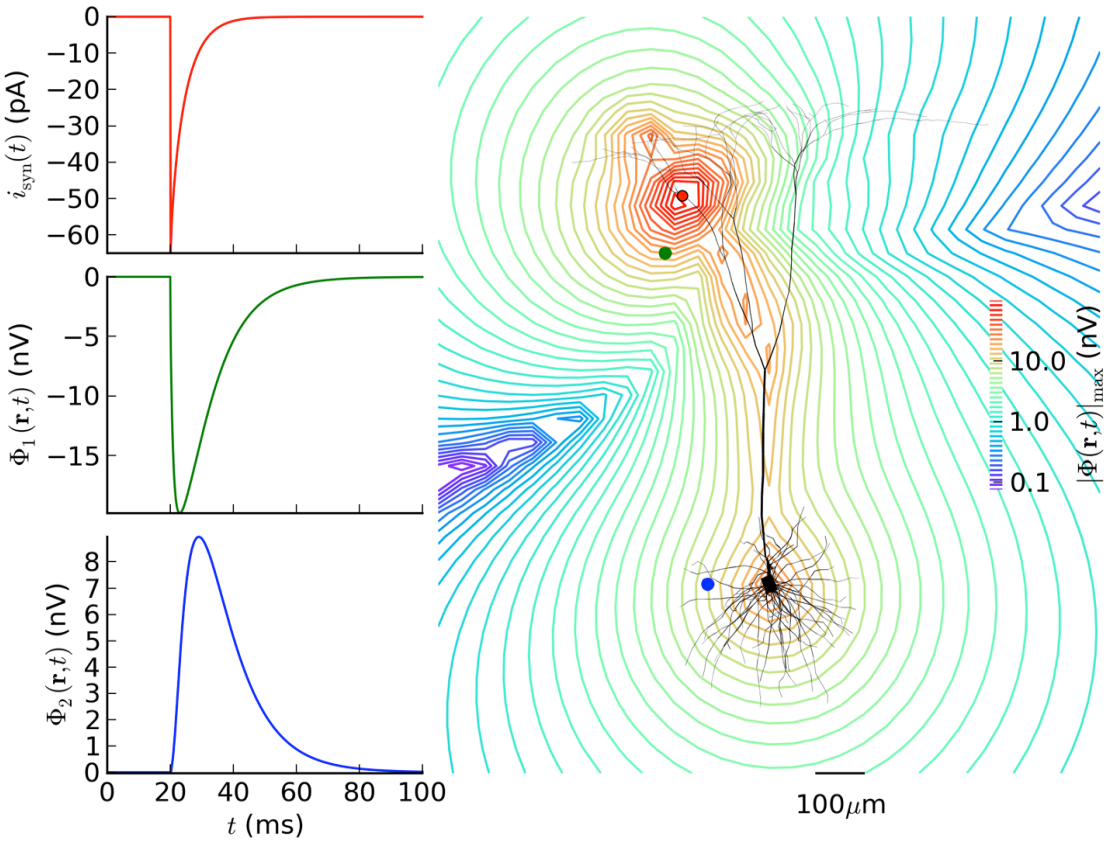
  `/path/to/LFPy/examples/`
- `.mod`-files may be compiled for active stuff, running

  `nrnivmodl`

  inside the examples folder

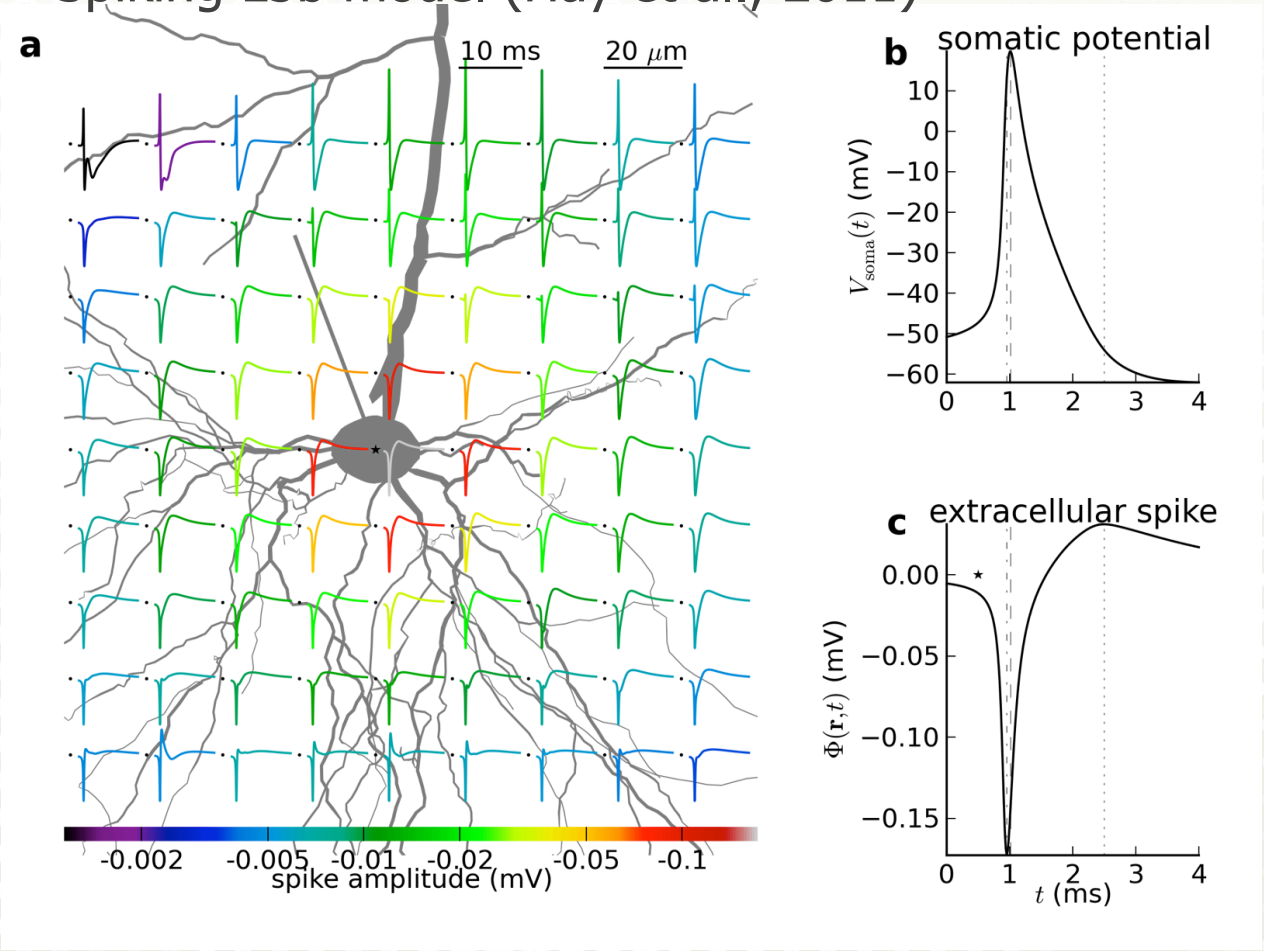
`LFPy` - Provided example files

- **`/path/to/LFPy/examples/example1.py`**:
  - Single apical synapse response. Passive membrane



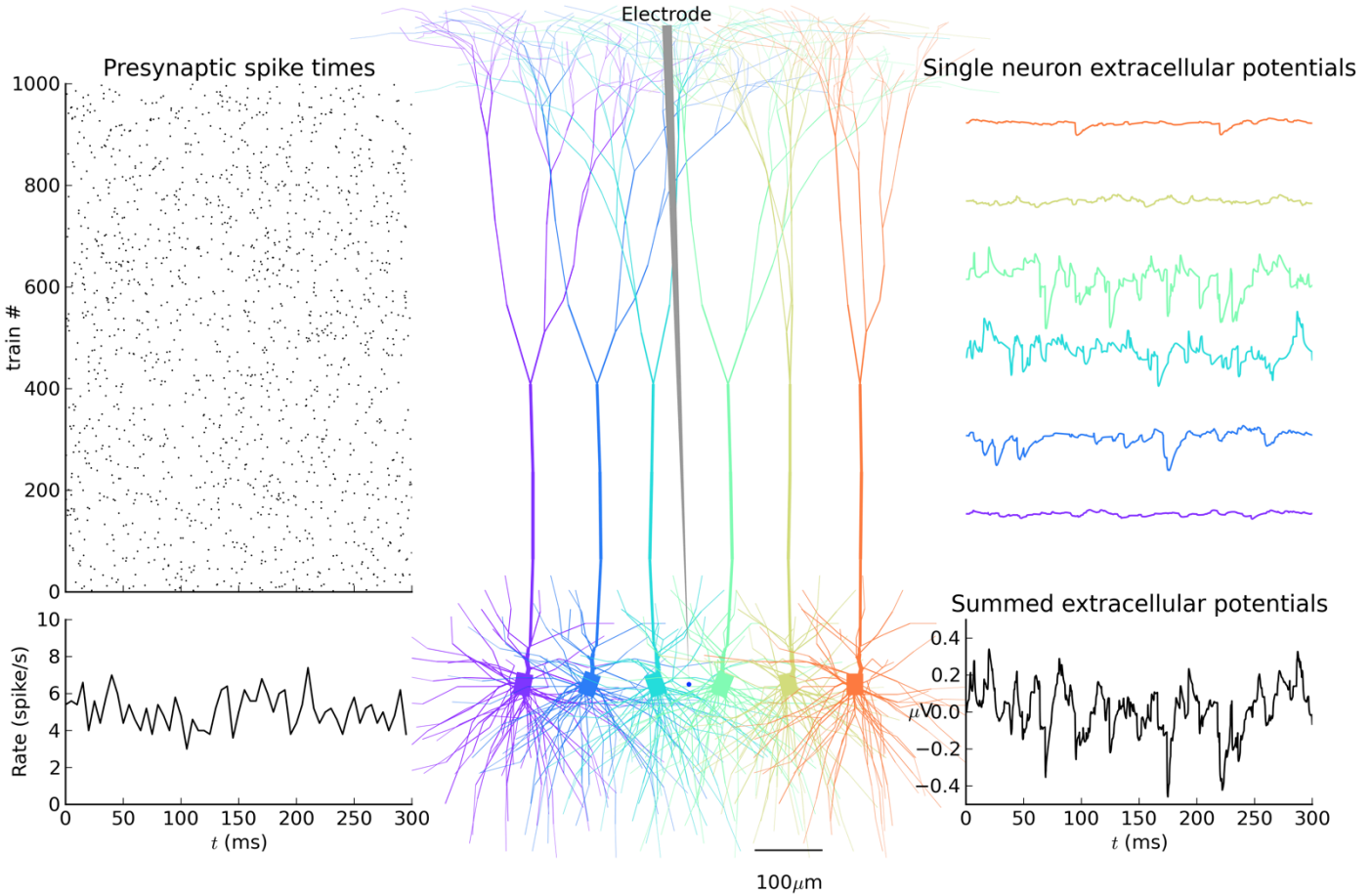
`LFPy` - Provided example files

- **`/path/to/LFPy/examples/example2.py`**:
  - Spiking L5b model (Hay et al., 2011)



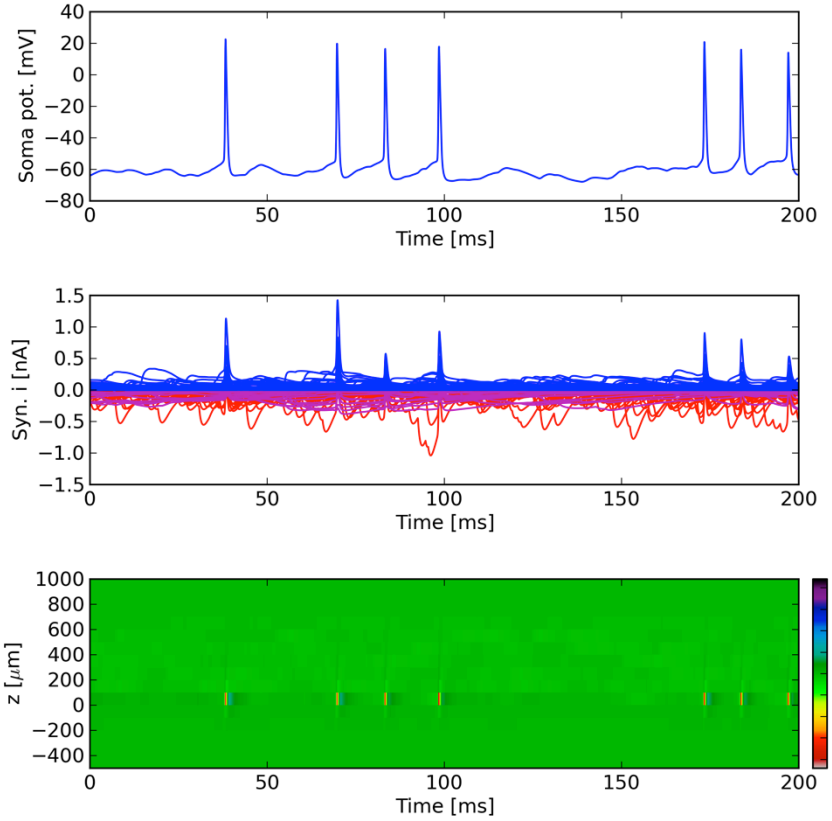
`LFPy` - Provided example files

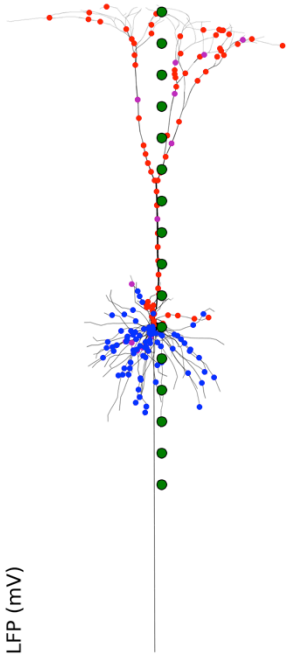
- **`/path/to/LFPy/examples/example3.py`**:
  - Hybrid model approach with MPI



`LFPy` - Provided example files

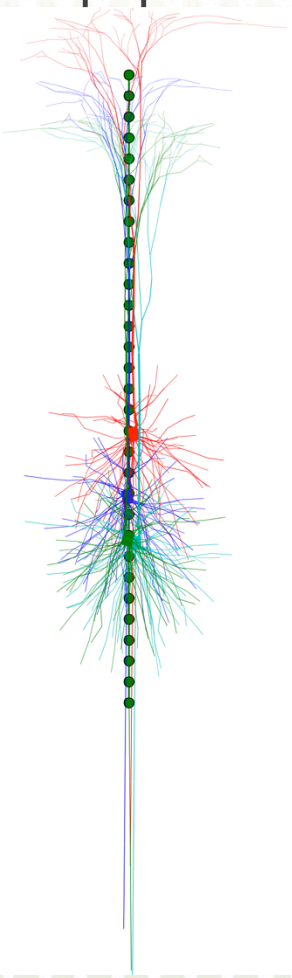
- **`/path/to/LFPy/examples/example6.py`**:
  - Distributed exc/inh. synapses. Active membrane.

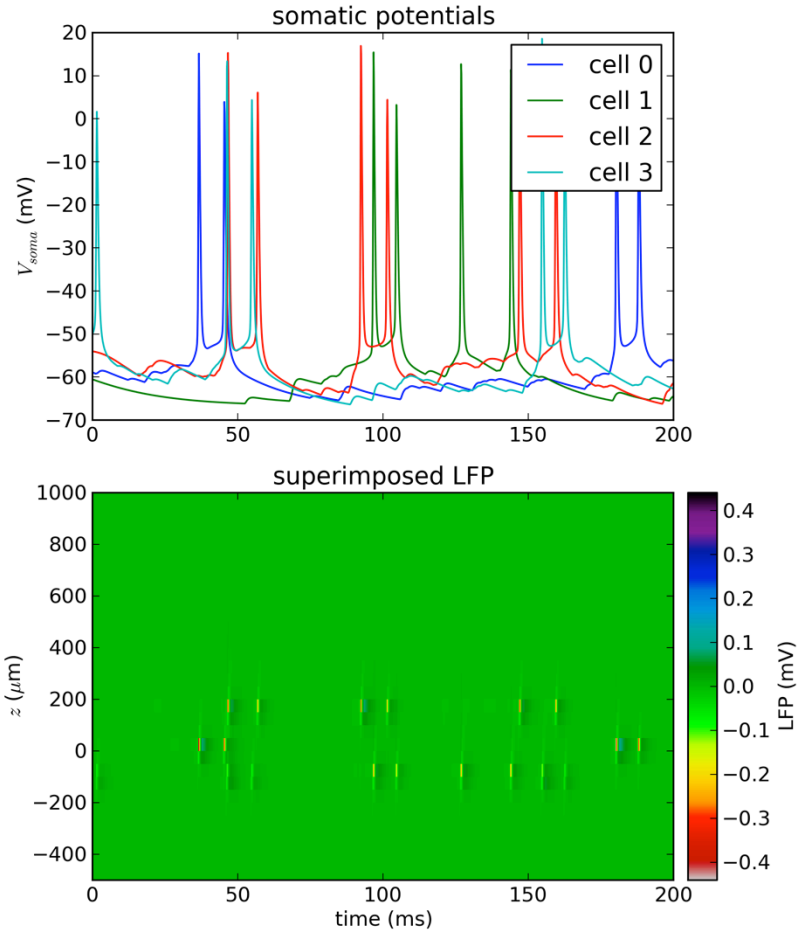




`LFPy` - Provided example files

- **`/path/to/LFPy/examples/example_mpi.py`**:
  - A small population using MPI. Active membranes.





LFPy - Tutorial

- Questions?
- If not, feel free to test out LFPy ☺