python

# tutorial : modeling synaptic plasticity

"Computational Neuroscience by the Mediterranean"

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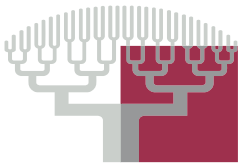
slides & scripts: http://www.biomedicale.univ-paris5.fr/~mgraupe/beirut_python



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# Outline

1. General introduction

   why python, installation, running python

2. First steps

   syntax, modules and functions

   (interactive IPython Notebook)

3. Brian introduction

   simulating a spiking recurrent network

   (interactive IPython Notebook)

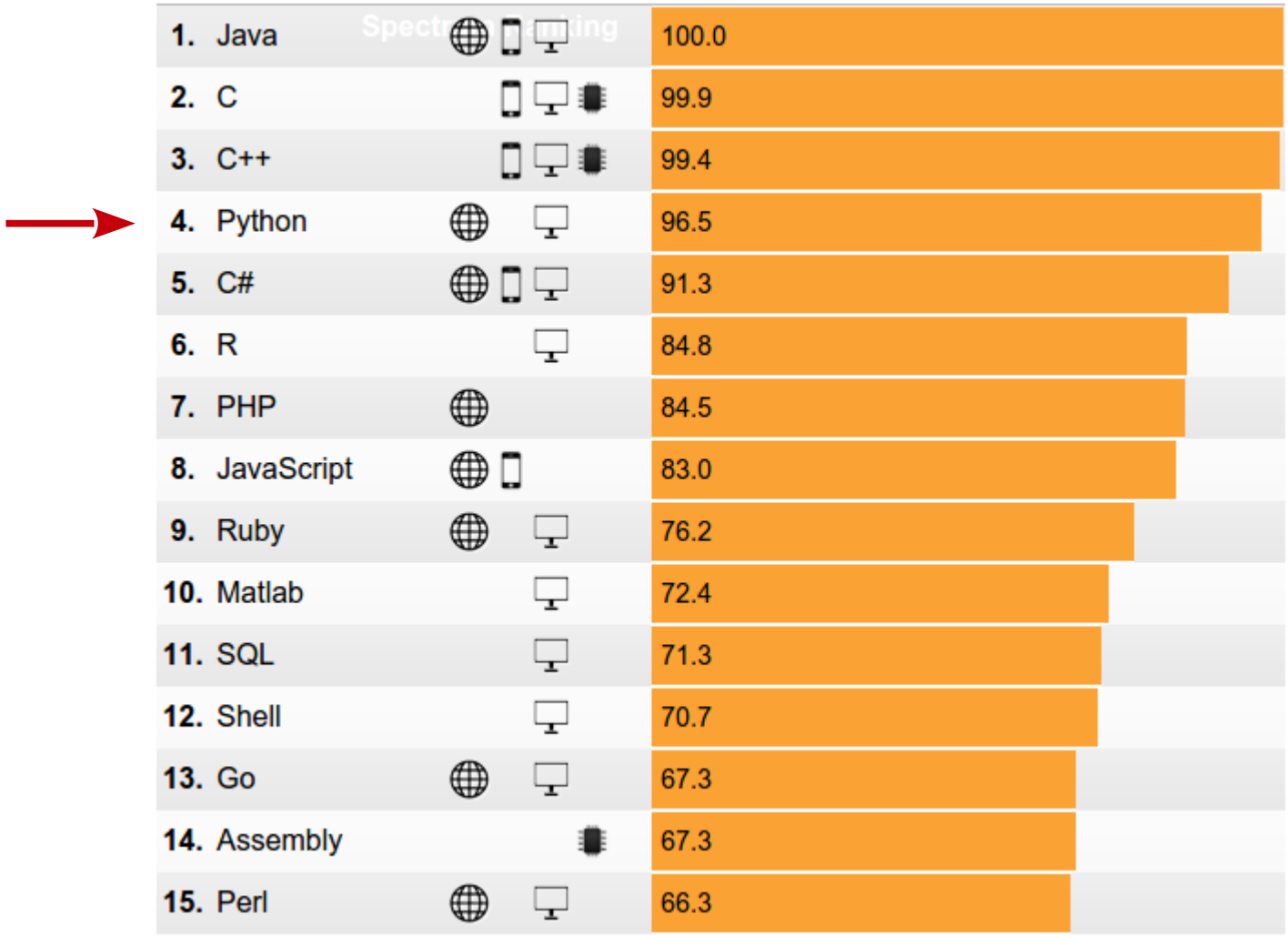
4. Modeling calcium-based synaptic plasticity

   building a model simulation in python - exercises

   (interactive IPython Notebook)

# Python – modern object-oriented programming language

The Top Programming Languages 2015



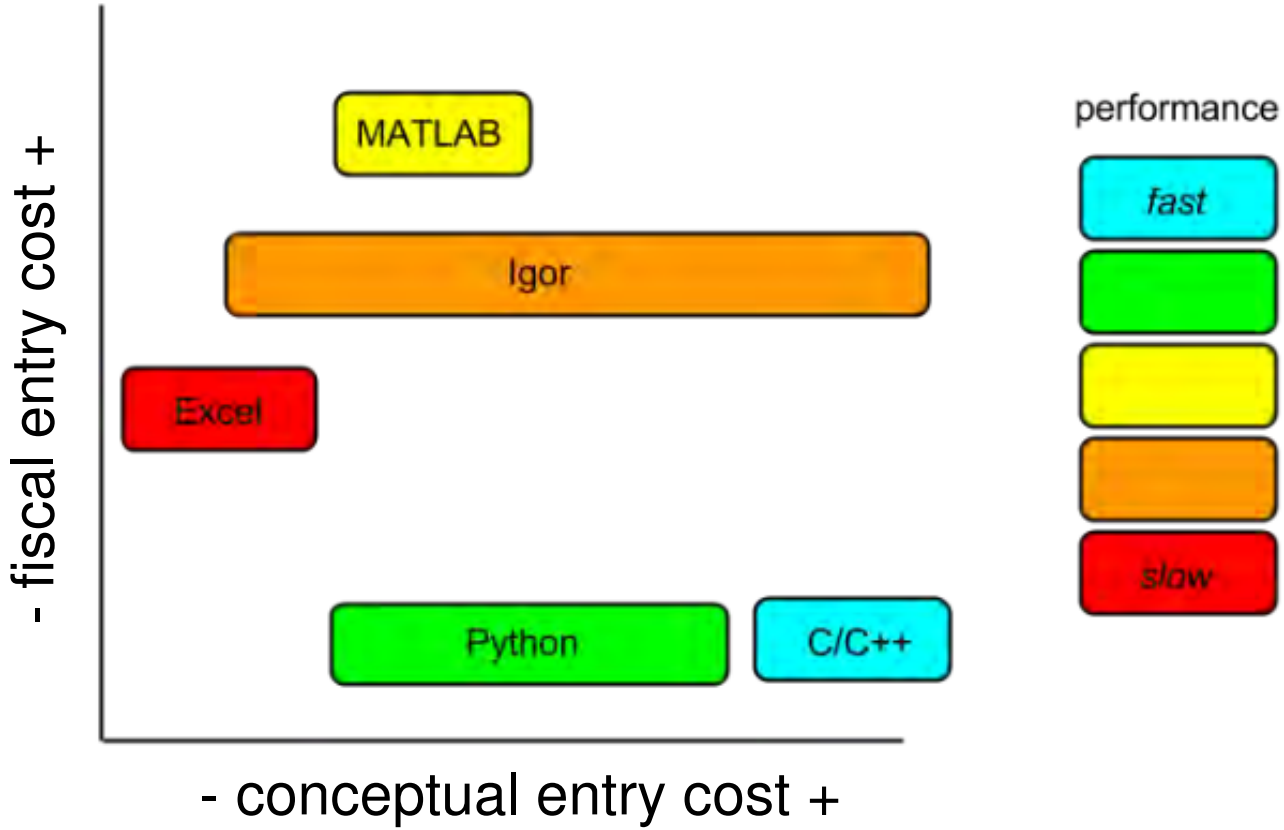

[Source : IEEE Spectrum]

# Python – very clear, readable syntax → easy to learn

In [1]:
```
# import modules
from pylab import *

# function declaration
def update_values(x):
    return x+1

x = 1
if x>0:
    print 'Hello World!'
    x = update_values(x)

print x
```

```
Hello World!
2
```

# Python – extensive standard libraries, “Batteries included”



# Python – third party extensions for virtually every task:

e.g. Python bindings for GUI toolkit

# Python modules for Neuroscience

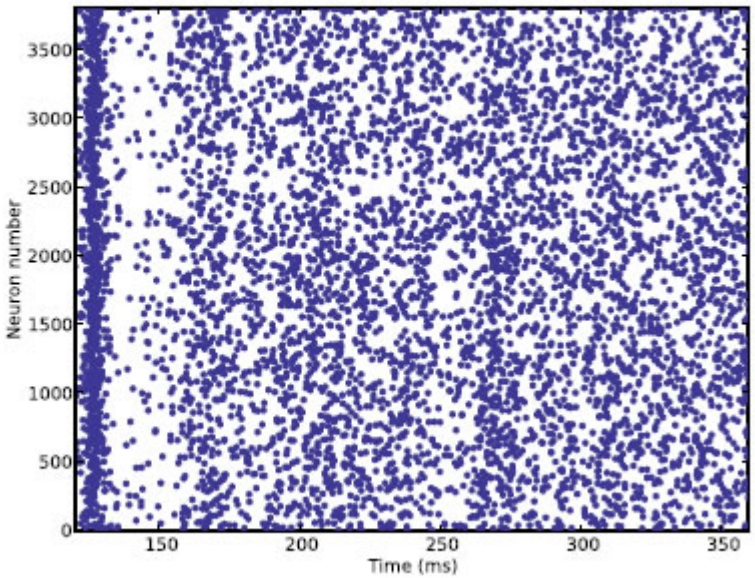
- simulators and simulator interfaces
- data collection and analysis
- sharing, re-use, storage and databasing of models and data
- stimulus generation
- parameter search and optimization
- visualization
- VLSI (very-large-scale integration) hardware interfacing

# Py in Neuroscience : simulators and simulator interfaces

e.g. Brian – the spiking neural network simulator


recurrent, randomly connected network

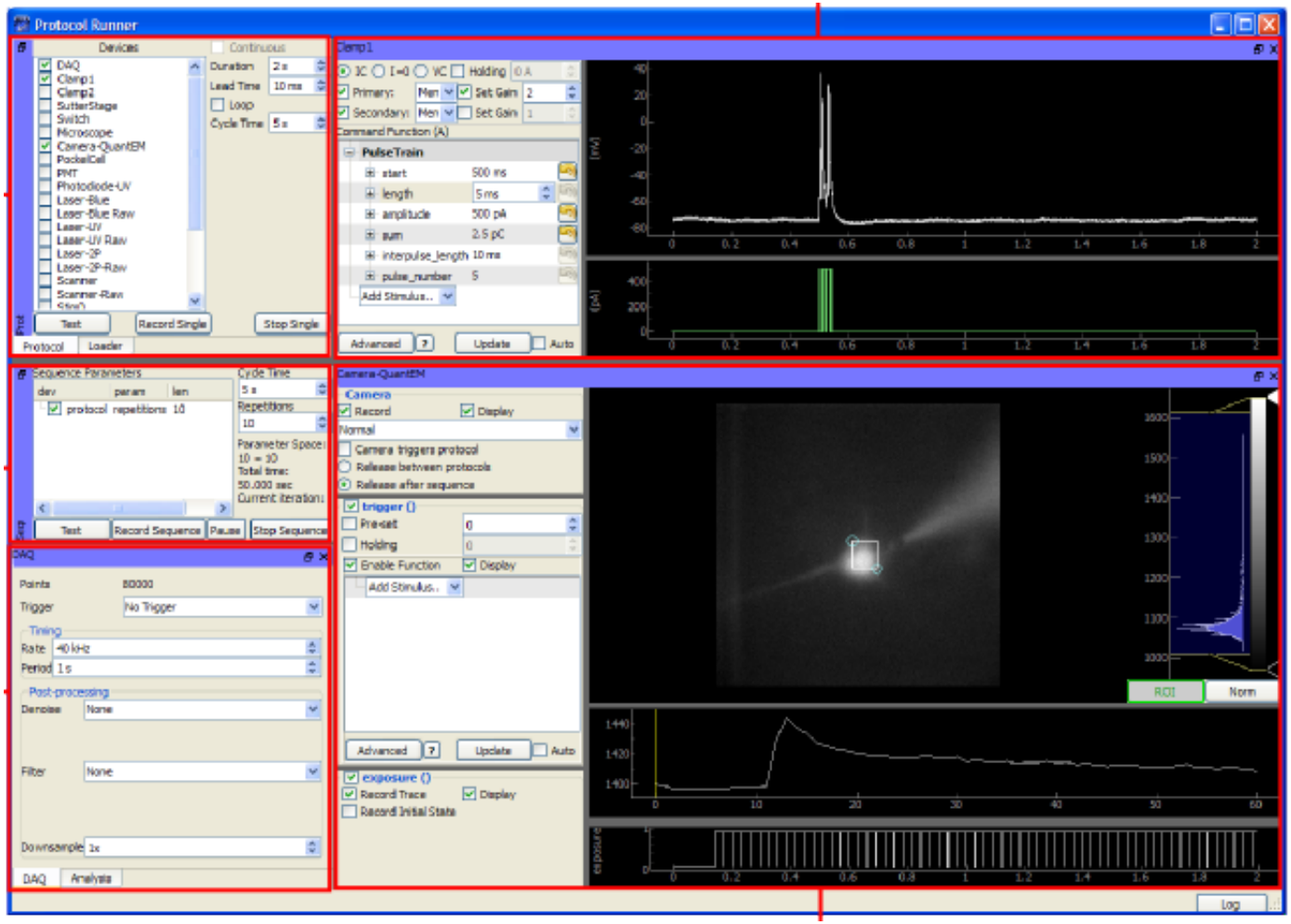
```
from brian import *
eqs = '''
dv/dt = (ge+gi-(v+49*mV))/(20*ms) : volt
dge/dt = -ge/(5*ms) : volt
dgi/dt = -gi/(10*ms) : volt
'''
P = NeuronGroup(4000, eqs, threshold=-50*mV, reset=-60*mV)
P.v = -60*mV+10*mV*rand(len(P))
Pe = P.subgroup(3200)
Pi = P.subgroup(800)
Ce = Connection(Pe, P, 'ge', weight=1.62*mV, sparseness=0.02)
Ci = Connection(Pi, P, 'gi', weight=-9*mV, sparseness=0.02)
M = SpikeMonitor(P)
run(1*second)
raster_plot(M)
show()
```




e.g. Python interface for NEURON

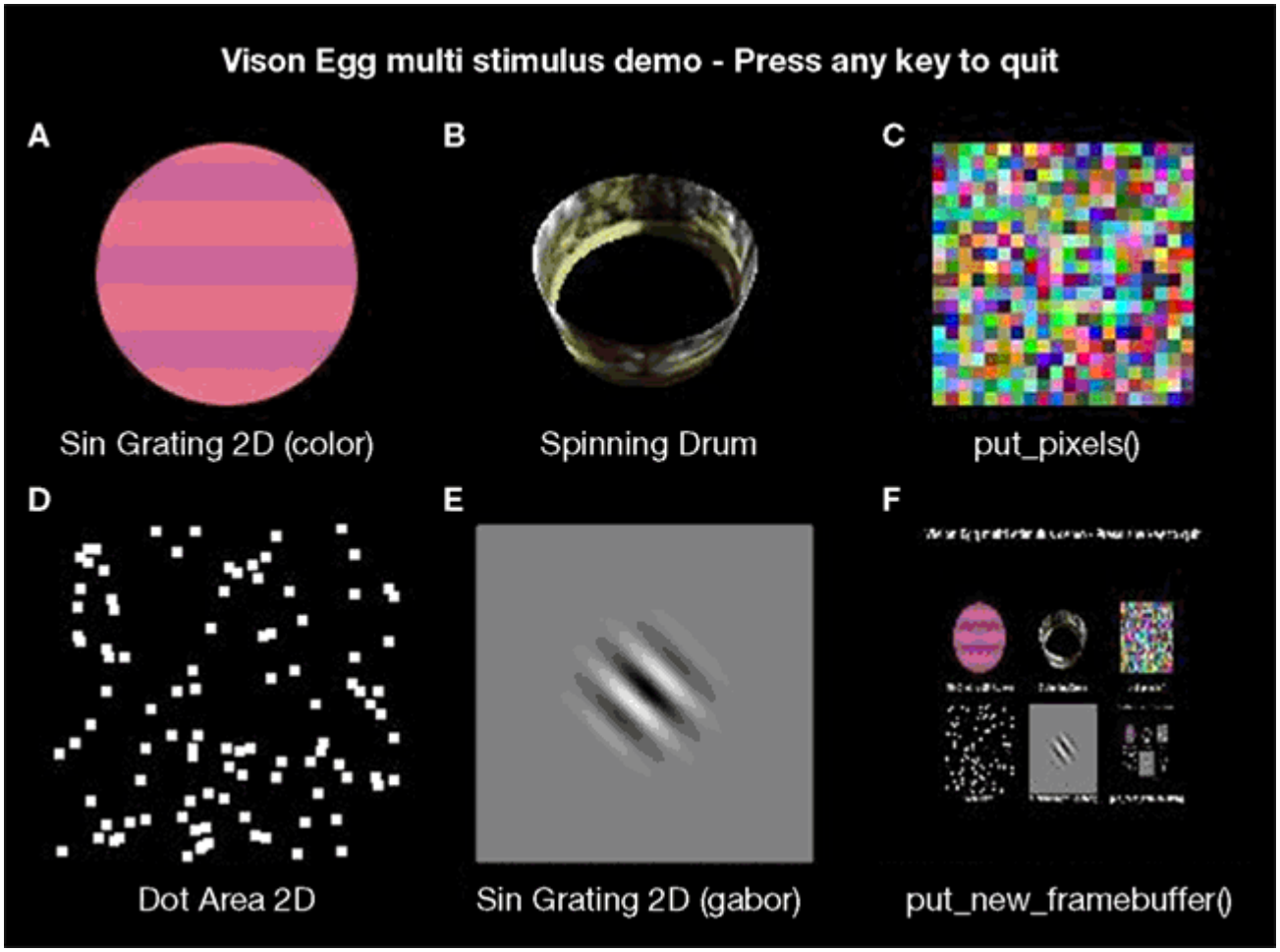
# Py in Neuroscience : data collection and analysis

e.g. ACQ4



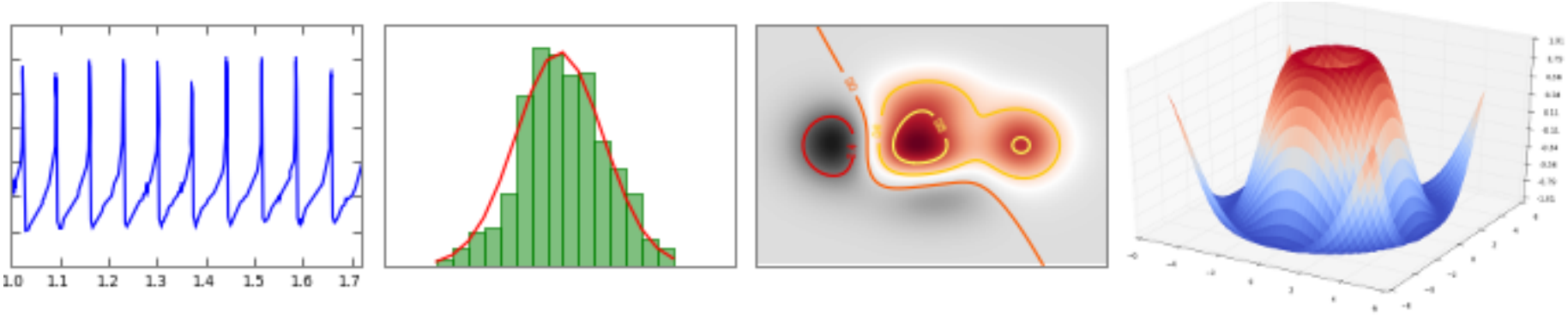
# Py in Neuroscience : stimulus generation

e.g. Vision EGG, or PsychoPy



# Py in Neuroscience : visualization

e.g. matplotlib library



# Getting started : Python installation

- Debian + Ubuntu Linux

```
apt-get install python-numpy python-scipy python-matplotlib \
ipython
```

- Windows, Mac OS X (distributions for package handling)

  - Enthought Python : https://www.enthought.com/

  - Anaconda from Continuum Analaytics : https://www.continuum.io/downloads

  - Python(x,y) http://python-xy.github.io/

- Alternative for Mac OS X : Install Fink, then

```
fink install scipy-core-py25 scipy-py25 matplotlib-py25 ipython-py25
```

# Getting started : interpreters and IDEs

- **ipython**

  - An interactive shell for with enhanced introspection, code highlighting and tab completion

- **Jython**

  - Another Python interpreter, written in Java instead of C

- **IronPython**

  - a python implementation for the .NET framework

  - integrates nicely with other .NET languages

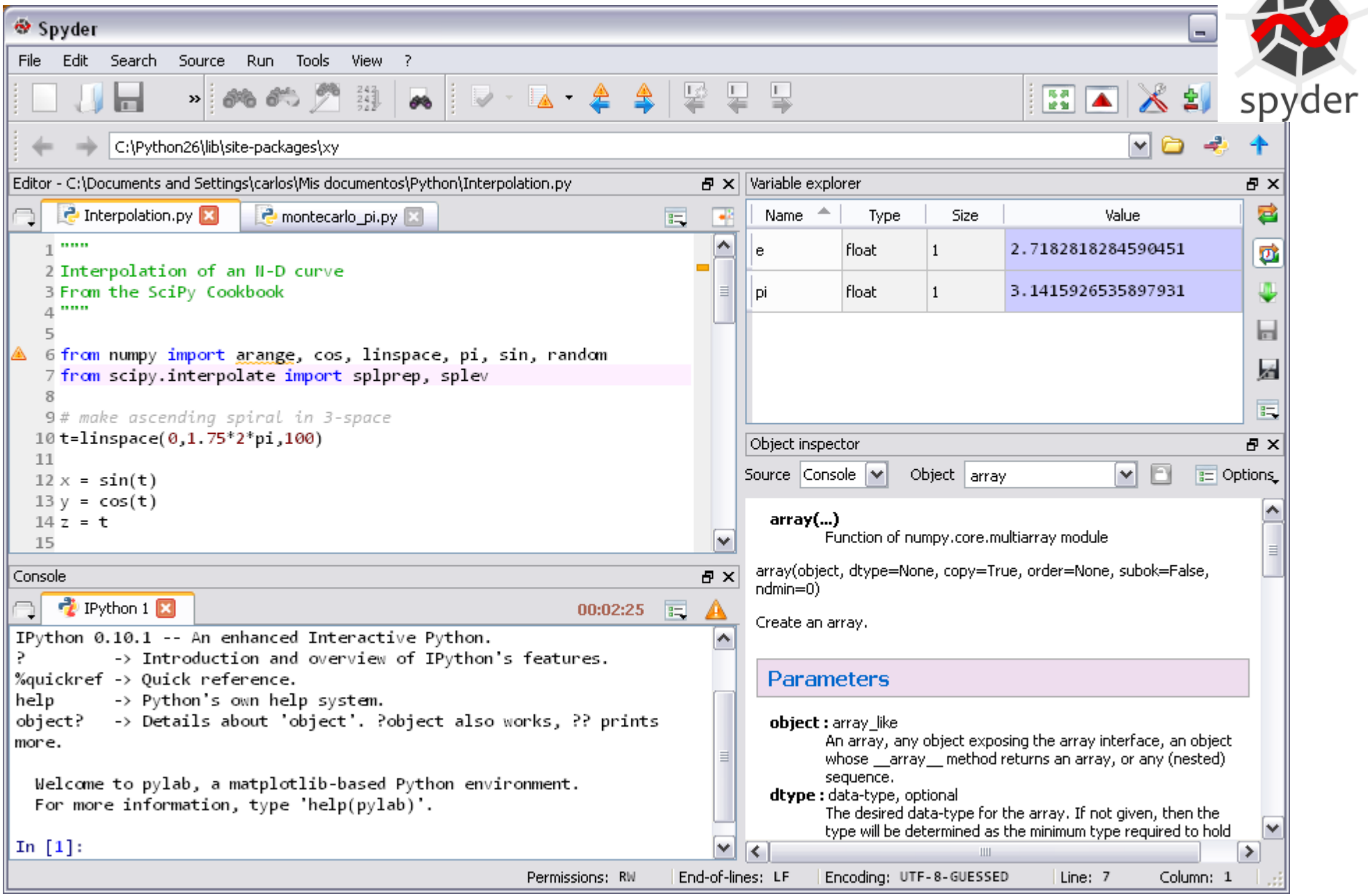
- **Spyder** : Scientific PYthon Development EnviRonment

- **IPython Notebook**

  - interactive shell in the browser

  - combines code execution, rich text, mathematics, plots and rich media

# Spyder screenshot



# IPython Notebook

IPython
Interactive Computing

IPy IPython Dashboard | IPy spectrogram

127.0.0.1:8888/a5222740-848b-4ac1-b212-d732c9f8f78b

IP[y]: Notebook spectrogram Last saved: Mar 07 11:14 PM

File Edit View Insert Cell Kernel Help

Markdown

## Simple spectral analysis

An illustration of the Discrete Fourier Transform

$$X_k = \sum_{n=0}^{N-1} x_n e^{-\frac{2\pi i}{N} kn} \qquad k = 0, \ldots, N-1$$

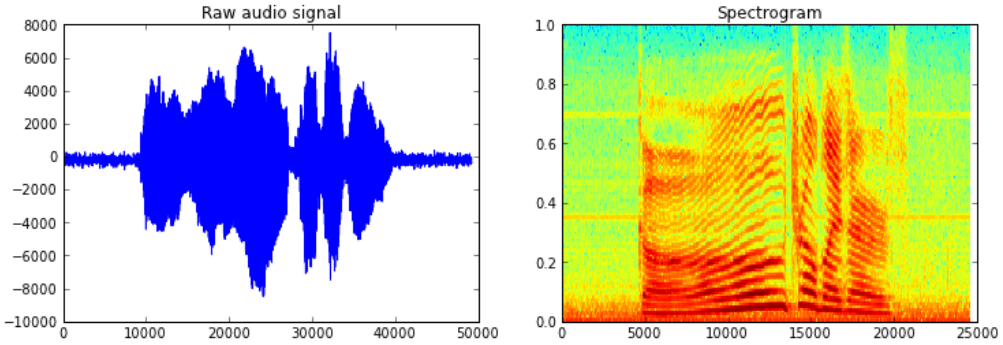
using windowing, to reveal the frequency content of a sound signal.

We begin by loading a datafile using SciPy's audio file support:

In [1]:
```
from scipy.io import wavfile
rate, x = wavfile.read('test_mono.wav')
```

And we can easily view its spectral structure using matplotlib's builtin `specgram` routine:

In [2]:
```
fig, (ax1, ax2) = plt.subplots(1, 2, figsize=(12, 4))
ax1.plot(x); ax1.set_title('Raw audio signal')
ax2.specgram(x); ax2.set_title('Spectrogram');
```



# Executing Python programs

- Python programs can be run either interactively or as scripts stored in a file
- The interpreter is started by calling **python**

```
mgraupe@thinkpadx1:~> python
Python 2.7.10 (default, Oct 14 2015, 16:09:02)
Type "help", "copyright", "credits" or "license"
for more information.
>>> print 'Hello world!'
Hello world!
>>> x = 3
>>> print x+5
8
```

- Scripts are supplied as arguments to the interpreter

```
mgraupe@thinkpadx1:~> python hello_world.py
Hello world!
```

- **python -i** gives an interactive prompt after the script

# Python scripts

- The default extension for Python files is **.py**
- Scripts start with the interpreter they should use

```
#! /usr/bin/env python
print 'Hello world!'
```

- Optionally, you can specify the file encoding in line 2

```
#! /usr/bin/env python
# * coding: utf8 *
print 'Total: 42  €'
```

- Scripts have to be executable : **chmod u+x <file>**
- Execute scripts as standalone programs

```
mgraupe@thinkpadx1:~> ./hello_world.py
Hello world!
```

# Online Resources - General

- The Python documentation index :

  `https://docs.python.org/2.7/`
- Python library reference :

  `https://docs.python.org/2.7/library/`
- Dive into Python

  `http://www.diveintopython.net/`
- Activestate Python cookbook :

  `http://aspn.activestate.com/ASPN/Cookbook/Python`
- The Python Tutorial :

  `https://docs.python.org/2/tutorial/index.html`
- Tentative Numpy Tutorial :

  `http://www.time.mk/trajkovski/teaching/imi/2010-fall/NumPy/Tentative%20NumPy%20Tutorial%20-.html`
- Scipy Reference :

  `http://docs.scipy.org/doc/scipy/reference/genindex.html`

# Online Resources - Neuroscience

- Front Neuroinform 2015 – *Python in Neuroscience :*

  `http://journal.frontiersin.org/article/10.3389/fninf.2015.00011/full`

- BCCN/FACETS Student Workshop - *Using Python for Computational*

  `http://neuralensemble.org/cookbook/wiki/FacetsPythonCourse2008`

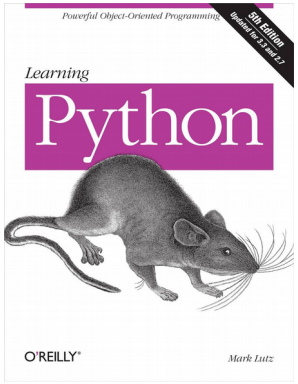
- BCCN course - *Advanced Scientific Programming in Python* :

  `https://python.g-node.org/wiki/schedule`

- Brian simulator :

  `http://briansimulator.org/`

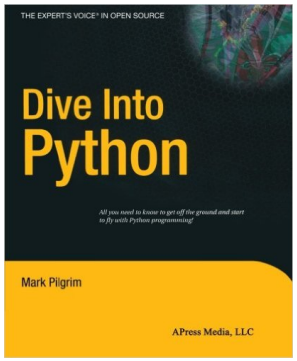
# Books




- Learning Python, 5th Edition

  Mark Lutz

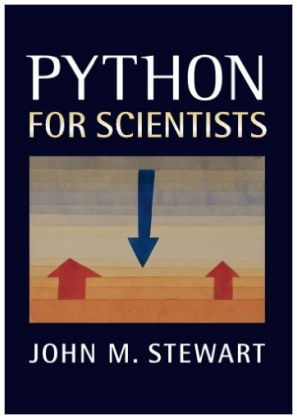
  ISBN : 978-1-4493-5573-9




- Dive Into Python (3)

  Mark Pilgrim

  ISBN: 978-1590593561 (978-1430224150)




- Python for Scientists

  John M. Stewart

  ISBN: 978-1107686427