IPython: Python at your fingertips

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Brian E. Granger (Cal Poly San Luis Obispo), Min Ragan-Kelley (UC Berkeley)
Thomas Kluyver (U Sheffield), Evan Patterson (Enthought).

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March 9, 2012

Why IPython?

I is for interactive...

In scientific computing,
we typically don't know what we're doing.

Exploratory computing is *not just for scientists*

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Python: an excellent *base* for an interactive environment

I said *a base...*

/bin/bash

```
dreamweaver[~]> python
Python 2.6.6 (r266:84292, Sep 15 2010, 16:22:56)
[GCC 4.4.5] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> ls
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'ls' is not defined
>>>
```

Mmh, introspection?

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>>> os?
  File "<stdin>", line 1
    os?
      ^
SyntaxError: invalid syntax
>>>
```

Basic comforts?

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SyntaxError: invalid syntax
>>> execfile('~/scratch/err.py')
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
IOError: [Errno 2] No such file or directory: '~/scratch/err.py'
>>>
```

Useful error info

/bin/bash

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SyntaxError: invalid syntax
>>> execfile('~/scratch/err.py')
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
IOError: [Errno 2] No such file or directory: '~/scratch/err.py'
>>> execfile('/home/fperez/scratch/err.py')
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
  File "/home/fperez/scratch/err.py", line 9, in <module>
    foo33
NameError: name 'foo33' is not defined
>>>
>>>
```

We can do better...

My files, thankyouverymuch

```
/bin/bash
dreamweaver[~]> ipython
Python 2.6.6 (r266:84292, Sep 15 2010, 16:22:56)
Type "copyright", "credits" or "license" for more information.

IPython 0.11.dev -- An enhanced Interactive Python.
?         -> Introduction and overview of IPython's features.
%quickref -> Quick reference.
help      -> Python's own help system.
object?   -> Details about 'object', use 'object??' for extra details.

In [1]: ls ~/scratch/er*py
/home/fperez/scratch/err25.py      /home/fperez/scratch/error.py*
/home/fperez/scratch/err_comps.py  /home/fperez/scratch/err.py

In [2]:
```

Some object details?

/bin/bash

```
Type:           module
Base Class:     <type 'module'>
String Form:    <module 'os' from '/usr/lib/python2.6/os.pyc'>
Namespace:      Interactive
File:           /usr/lib/python2.6/os.py
Docstring:
    OS routines for Mac, NT, or Posix depending on what system we're on.

    This exports:
      - all functions from posix, nt, os2, or ce, e.g. unlink, stat, etc.
      - os.path is one of the modules posixpath, or ntpath
      - os.name is 'posix', 'nt', 'os2', 'ce' or 'riscos'
      - os.curdir is a string representing the current directory ('.' or ':')
      - os.pardir is a string representing the parent directory ('..' or '::')
      - os.sep is the (or a most common) pathname separator ('/' or ':' or '\\')
      - os.extsep is the extension separator ('.' or '/')
      - os.altsep is the alternate pathname separator (None or '/')
      - os.pathsep is the component separator used in $PATH etc
      - os.linesep is the line separator in text files ('\r' or '\n' or '\r\n')
      - os.defpath is the default search path for executables
      - os.devnull is the file path of the null device ('/dev/null', etc.)

    Programs that import and use 'os' stand a better chance of being
lines 1-23
```

More info??

/bin/bash

```
Type:           module
Base Class:     <type 'module'>
String Form:    <module 'code' from '/usr/lib/python2.6/code.pyc'>
Namespace:      Interactive
File:           /usr/lib/python2.6/code.py
Source:
"""Utilities needed to emulate Python's interactive interpreter.

"""

# Inspired by similar code by Jeff Epler and Fredrik Lundh.


import sys
import traceback
from codeop import CommandCompiler, compile_command

__all__ = ["InteractiveInterpreter", "InteractiveConsole", "interact",
           "compile_command"]

def softspace(file, newvalue):
    oldvalue = 0
    try:
        oldvalue = file.softspace
    except AttributeError:
        pass
    try:
        file.softspace = newvalue
lines 1-28
```

When things go wrong

/bin/bash

```
In [13]: run ~/scratch/error
reps: 5
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
/home/fperez/scratch/error.py in <module>()
     70 if __name__ == '__main__':
     71     #explode()
     72
---> 72     main()
     73     g2='another global'

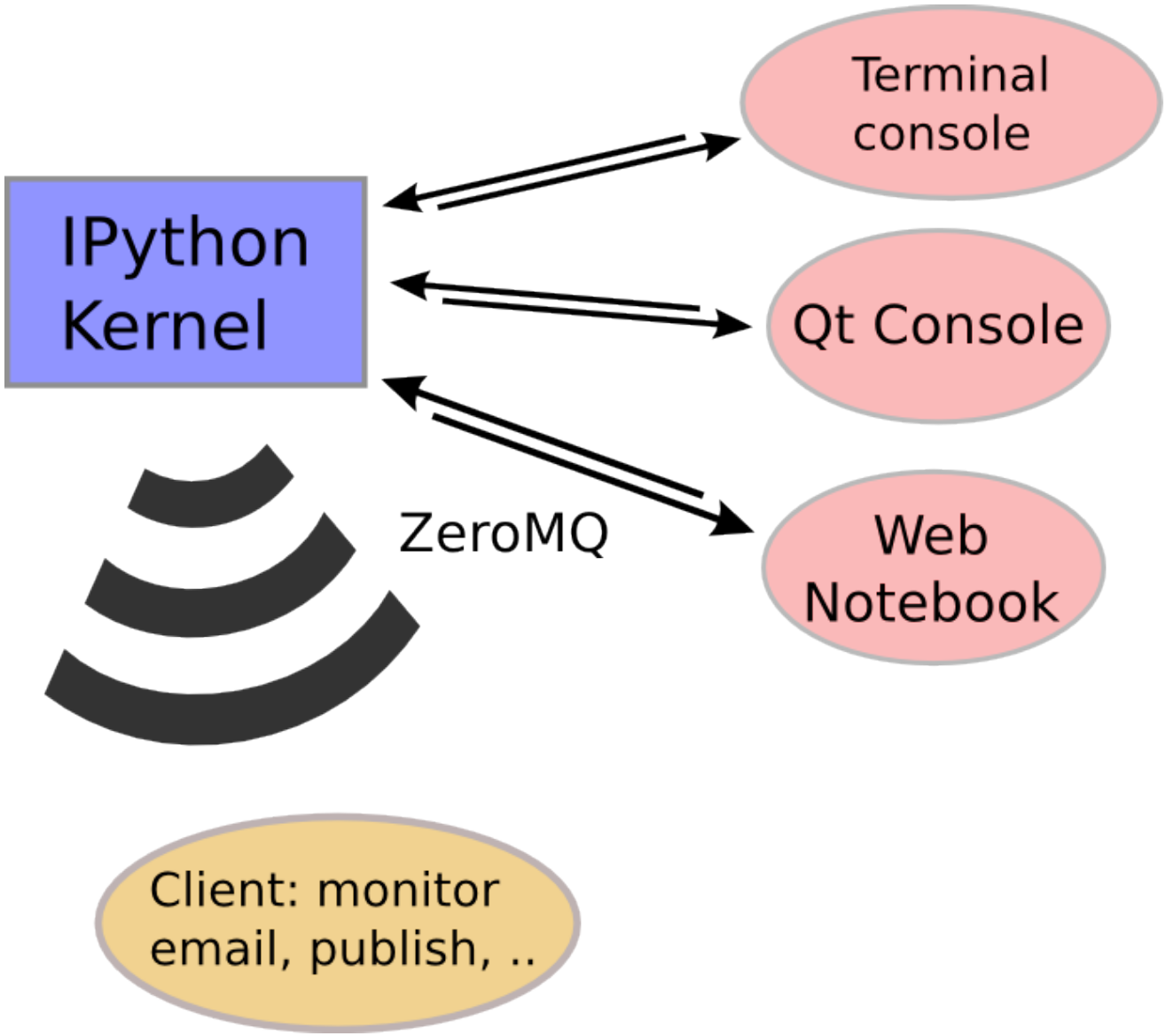
/home/fperez/scratch/error.py in main()
     60     array_num = zeros(size,'d')
     61     for i in xrange(reps):
---> 62         RampNum(array_num, size, 0.0, 1.0)
     63     RNtime = time.clock()-t0
     64     print 'RampNum time:', RNtime

/home/fperez/scratch/error.py in RampNum(result, size, start, end)
     43     tmp = zeros(size+1)
     44     step = (end-start)/(size-1-tmp)
---> 45     result[:] = arange(size)*step + start
     46
     47 def main():

ValueError: shape mismatch: objects cannot be broadcast to a single shape

In [14]:
```

Interactive architecture



Terminal console with visualization

fperez@longs:/home/fperez - Shell - Konsole

```
longs[~]> ipython -pylab
Python 2.4.3 (#2, Apr 27 2006, 14:43:58)
Type "copyright", "credits" or "license" for more information.

IPython 0.7.3.svn -- An enhanced Interactive Python.
?       -> Introduction to IPython's features.
%magic  -> Information about IPython's 'magic' % functions.
help    -> Python's own help system.
object? -> Details about 'object'. ?object also works, ?? prints more.

  Welcome to pylab, a matplotlib-based Python environment.
  For more information, type 'help(pylab)'.

In [1]: import math, numpy

In [2]: from scipy.integrate import quad

In [3]: from scipy.special import j0

In [4]: def j0i(x):
   ...:     """Integral form of J_0(x)"""
   ...:     def integrand(phi):
   ...:         return math.cos(x*math.sin(phi))
   ...:     return (1.0/math.pi)*quad(integrand,0,math.pi)[0]
   ...:

In [5]: x = numpy.linspace(0,20,200) # sample grid: 200 points between 0 and 20

In [6]: y = j0(x)  # sample J0 at all values of x

In [7]: x1 = x[::10]  # subsample the original grid every 10th point

In [8]: y1 = map(j0i,x1)  # evaluate the integral form at all points in x1

In [9]: # Make a plot with these values (the ; suppresses output)

In [10]: plot(x,y,label=r'$J_0(x)$');

In [11]: plot(x1,y1,'ro',label=r'$J_0^{\textrm{integ}}(x)$');

In [12]: axhline(0,color='green',label='_nolegend_');

In [13]: title(r'Verify $J_0(x)=\frac{1}{\pi}\int_0^{\pi}\cos(x \sin\phi)\,d\phi$');

In [14]: xlabel('$x$');

In [15]: legend();

In [16]: matshow(numpy.random.random((32,32)))
Out[16]: <matplotlib.figure.Figure instance at 0x4630042c>
```

Shell

Figure 1

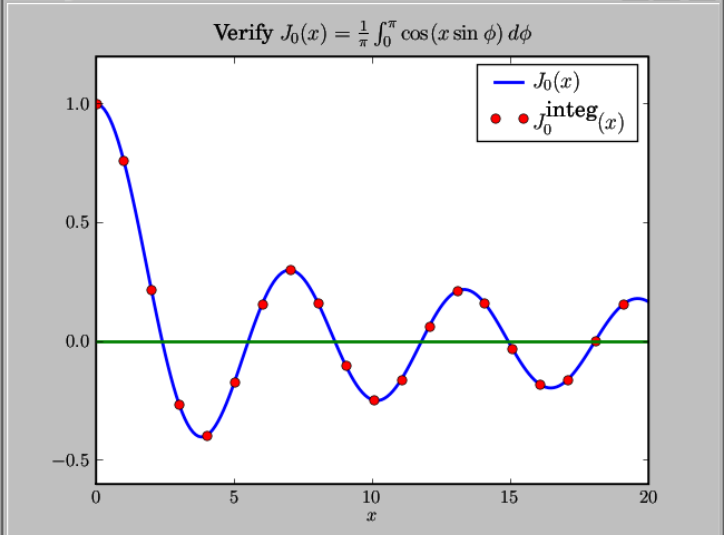
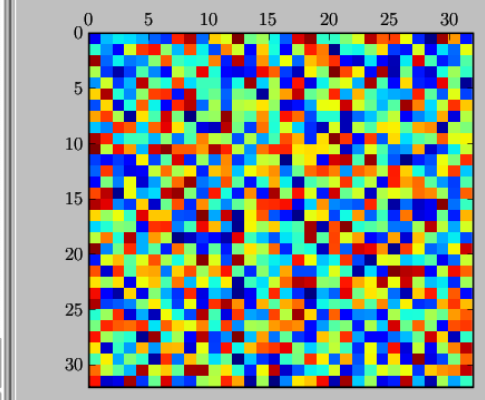


Figure 2



Qt console: inline plots, html, multiline editing, ...

Evan Patterson (Enthought)

IPython

File Edit View Kernel Magic Window Help

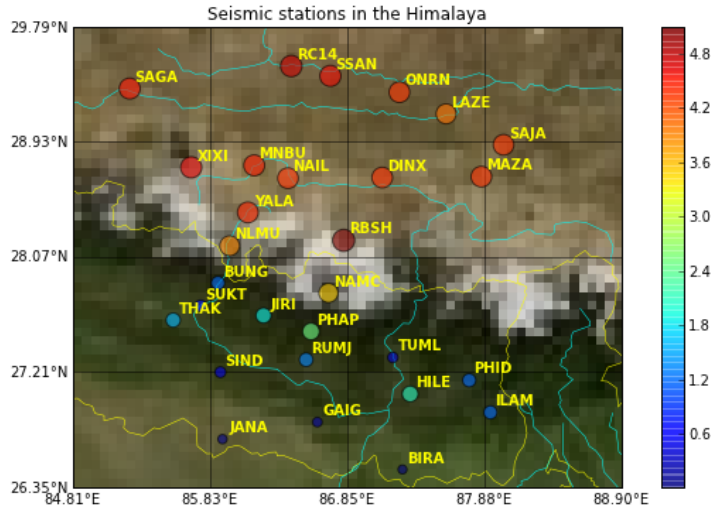
```
Python 2.7.2+ (default, Oct  4 2011, 20:06:09)
Type "copyright", "credits" or "license" for more information.

IPython 0.13.dev -- An enhanced Interactive Python.
?         -> Introduction and overview of IPython's features.
%quickref -> Quick reference.
help      -> Python's own help system.
object?   -> Details about 'object', use 'object??' for extra details.
%guiref   -> A brief reference about the graphical user interface.

Welcome to pylab, a matplotlib-based Python environment [backend:
module://IPython.zmq.pylab.backend_inline].
For more information, type 'help(pylab)'.

In [1]: import scipy.linalg as la
   ...: mineigs = []
   ...: n = 256
   ...: for i in range(10):
   ...:     a = rand(n, n)
   ...:     mineigs.append(la.eigvals(a).min().real)
   ...:
   ...: mean(mineigs)
Out[1]: -4.569467643237938

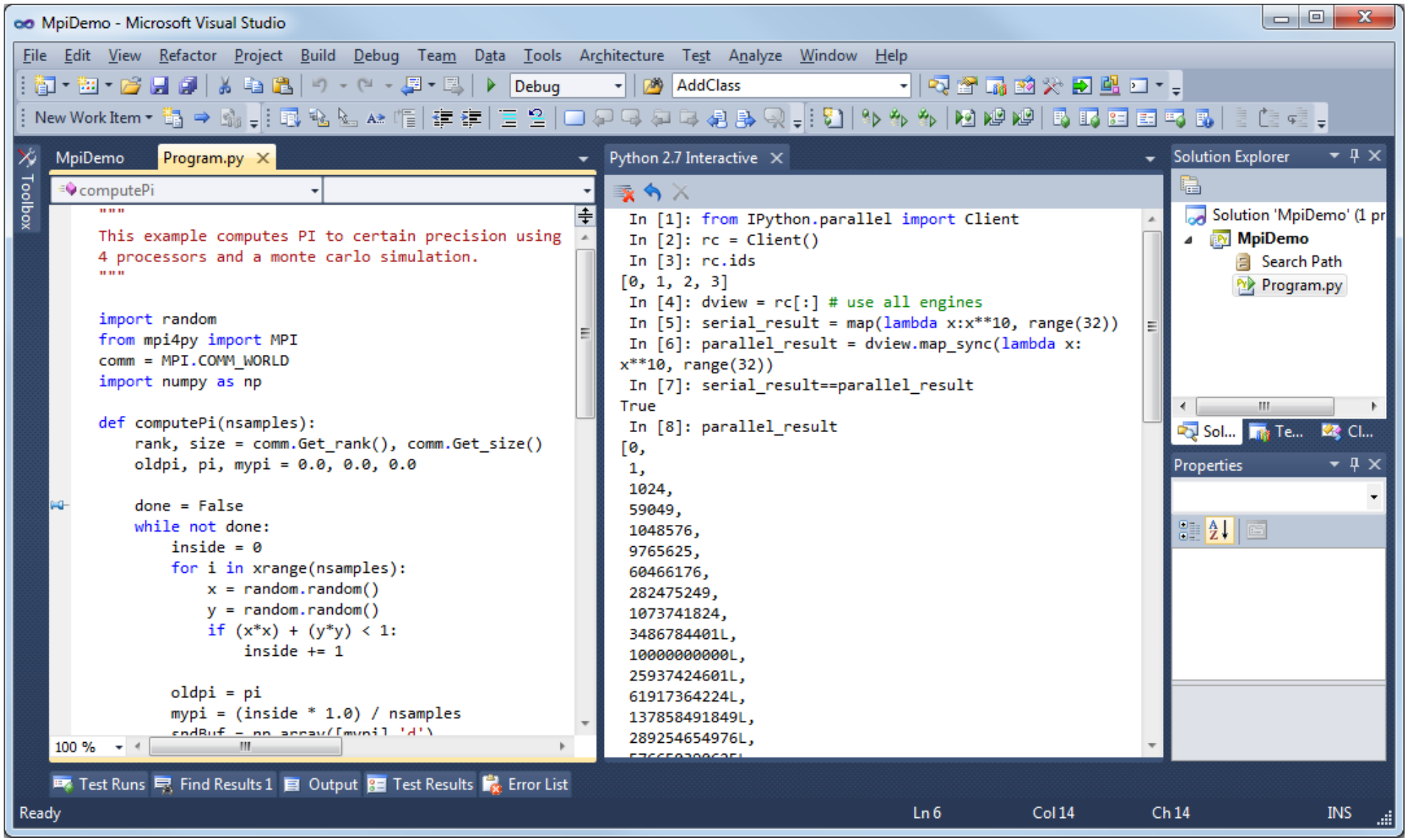
In [2]: %run mapping_seismic_stations.py
```




```
In [3]:
```

Microsoft Visual Studio 2010 integrated console

Dino Viehland and Shahrokh Mortazavi; http://pytools.codeplex.com



Browser-based notebook: rich text, code, plots, ...

Brian Granger, James Gao (Berkeley), rest of the team

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

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

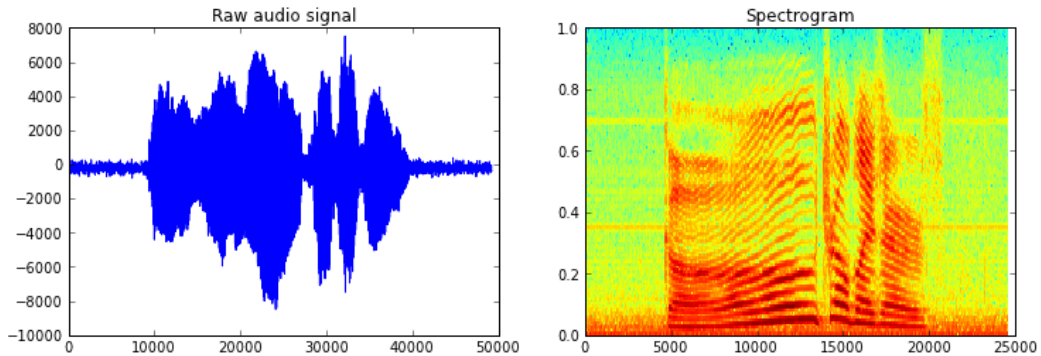
using windowing, to reveal the frequency content of a sound signal.

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')
```

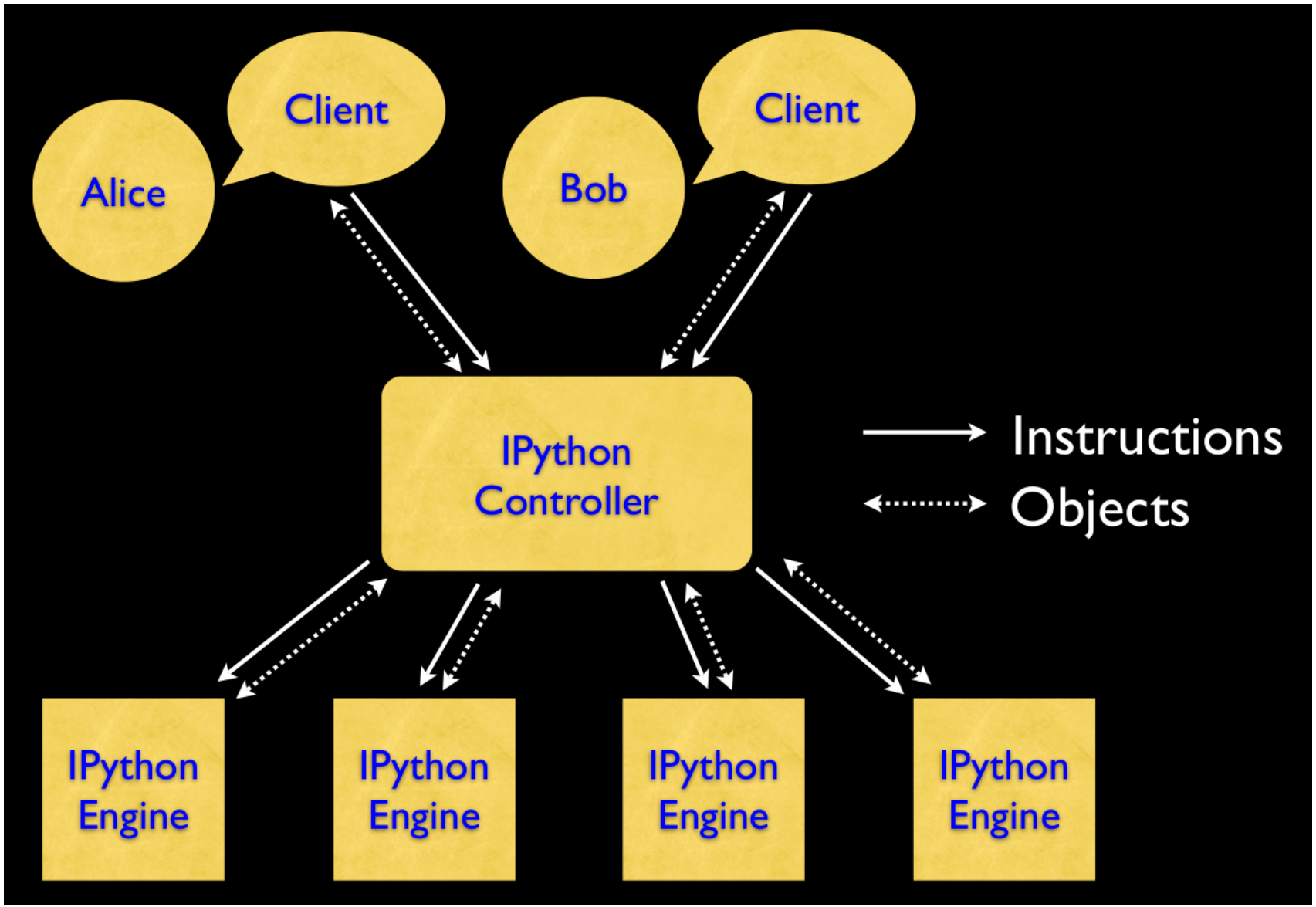
And we can easily view its spectral structure using matplotlib's builtin `specgram` routine:

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');
```



Interactive and high-level parallel APIs

Min Ragan-Kelley, Brian Granger



How did we get here?
A brief history of IPython

- **October/November 2001: "just a little afternoon hack"**
  - `$PYTHONSTARTUP: ipython-0.0.1.py` (259 lines)
  - IPP (Interactive Python Prompt) by Janko Hauser (Oceanography)
  - LazyPython by Nathan Gray (CalTech)
- **2002: Drop John Hunter's Gnuplot patches: matplotlib**
- **2004: Brian Granger, Min Ragan-Kelley: Parallel on Twisted...**
- **2005-2009: Mayavi, Wx support, refactoring; slow period.**
- **2010: discover ØMQ, Enthought support.**
  - Move to Git/Github.
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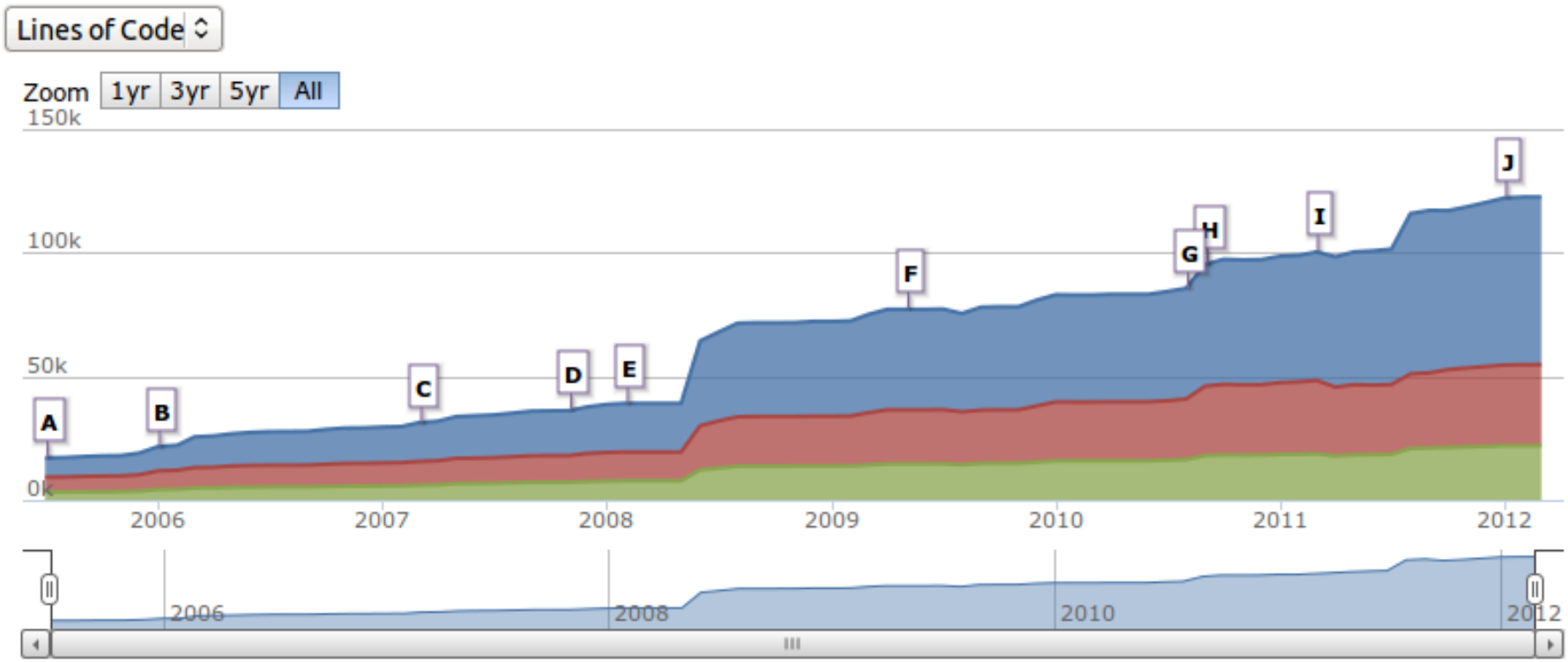
(Incomplete) Cast of Characters

- **Brian Granger** - Physics, Cal State San Luis Obispo
- **Min Ragan-Kelley** - UC Berkeley
- **Thomas Kluyver** - U. Sheffield
- **Jörgen Stenarson** - SP Technical Research Institute of Sweden
- **Paul Ivanov** - UC Berkeley
- **Robert Kern** - Enthought
- **Evan Patterson** - Caltech/Enthought
- Stefan van der Walt - UC Berkeley
- John Hunter - TradeLink Securities, Chicago.
- Prabhu Ramachandran - Aerospace Engineering, IIT Bombay
- Satra Ghosh- MIT Neuroscience
- Gaël Varoquaux - Neurospin (Orsay, France)
- Ville Vainio - CS, Tampere University of Technology, Finland
- Barry Wark - Neuroscience, U. Washington.
- Ondrej Certik - Physics, U Nevada Reno
- Darren Dale - Cornell
- Justin Riley - MIT
- Mark Voorhies - UC San Francisco
- Nicholas Rougier - INRIA Nancy Grand Est
- Thomas Spura - Fedora project
- Julian Taylor - Debian/Ubuntu
- Many more! (~140 commit authors)

Some quick stats. http://www/ohloh.net/p/ipython



Other projects using IPython

Scientific

- **EPD:** Enthought Python Distribution.
- **Sage**: open source mathematics.
- **PyRAF**: Space Telescope Science Institute
- **CASA**: Nat. Radio Astronomy Observatory
- **Ganga**: CERN
- **PyMAD**: neutron spectrom., Laue Langevin
- **Sardana**: European Synchrotron Radiation
- **ASCEND**: eng. modeling (Carnegie Mellon).
- **JModelica**: dynamical systems.
- **DASH**: Denver Aerosol Sources and Health.
- **Trilinos**: Sandia National Lab.
- **DoD**: baseline configuration.
- **Mayavi**: 3d visualization, Enthought.
- **NiPype**: computational pipelines, MIT.
- **PyIMSL** Studio, by Visual Numerics.
- ...

Web/Other

- **Visual Studio 2010**: MS.
- **Django**.
- **Turbo Gears**.
- **Pylons** web framework
- **Zope** and **Plone** CMS.
- Axon Shell, BBC **Kamaelia**.
- **Schevo** database.
- **Pitz**: distributed task/bug tracking.
- **iVR** (interactive Virtual Reality).
- **Movable Python** (portable Python environment).
- ...

Support
Thank you!

- **Enthought**, Austin, TX: **Lots!**
- Tech-X Corporation, Boulder, CO: Parallel/notebook (previous versions)
- Microsoft: WinHPC support, Visual Studio integration
- NIH: via NiPy grant
- NSF: via Sage compmath grant
- Google: summer of code 2005, 2010.
- DoD/HPTi: funding through Sept. 2012 (thanks to Jose Unpingco!).

IPython in brief

1. A better Python shell
2. Embeddable Kernel and powerful interactive clients
    1. Terminal
    2. Qt console
    3. Web notebook
3. Flexible parallel computing

`http://ipython.org`

`http://github.com/ipython`

Demo time!

Booth 201 - on your left by the entrance