

JOVIAL

JUPYTER OVERRIDE FOR ASTRONOMICAL LIBRARIES

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UNIVERSIDAD TECNICA FEDERICO SANTA MARIA



FONDEF
Fondo de Fomento al Desarrollo
Científico y Tecnológico

WHAT IS JOVIAL?

- Jupyter-based service for astronomical analysis
- Integrate **astronomical libraries** in web-based platform
- **Cloud service** of the Chilean Virtual Observatory
- Status: **alpha**, beta (Dec)



Cognitive Astronomy
Software Applications



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FEDERICO SANTA MARIA



WHAT JOVIAL IS NOT...

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- Yet another astronomical library
 - (we already try that last year)

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- Yet another astronomical library
 - (we already try that last year)
- Yet another astronomical GUI



2015 ASTRONOMICAL DATA ANALYSIS SYSTEMS AND SOFTWARE CONFERENCE

P102 Mauricio Solar

Technical University Federico Santa Maria

The ChiVO Library: Advanced Computational Methods for Astronomy.

The main objective of the Advanced Computational Astronomy Library (ACALib) is to ensemble a coherent software package with the research on computational methods for astronomy performed by the first phase of the Chilean Virtual Observatory between years 2013 and 2015. During this period, researchers and students developed functional prototypes, implementing state of the art computational methods and proposing new algorithms and techniques. This research was mainly

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 - (too many good competitors)



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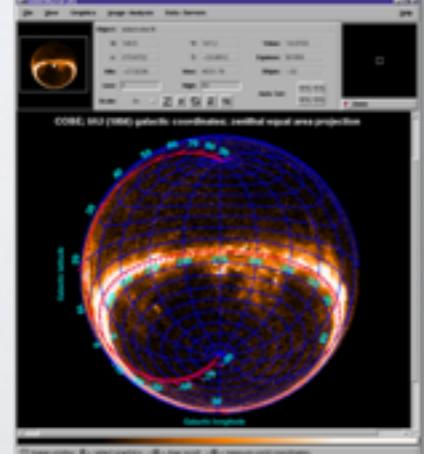
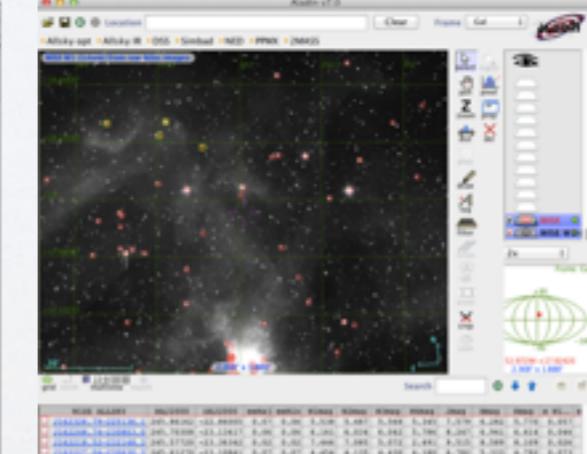
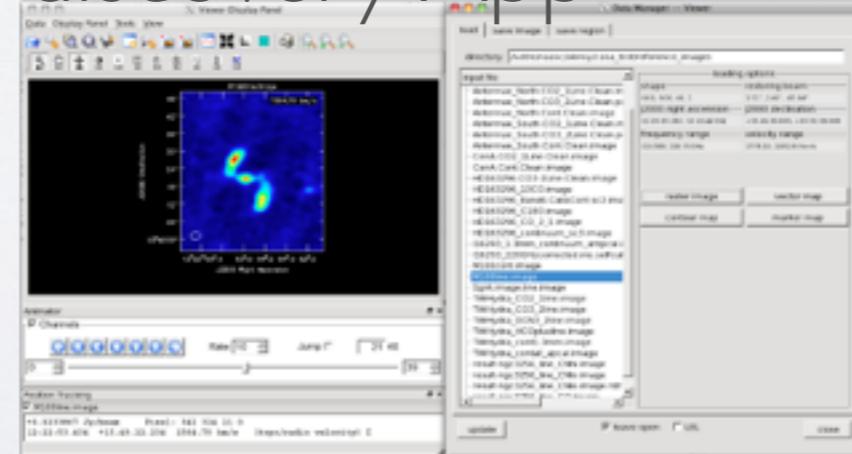
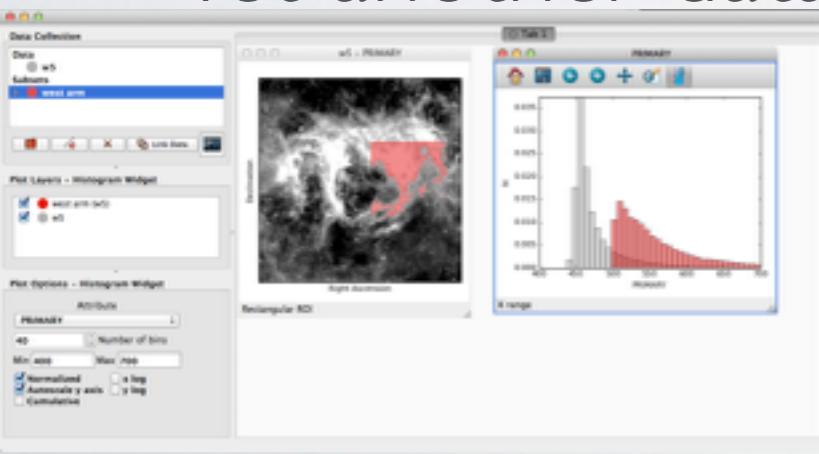
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- Yet another data discovery App



ADASS XXV 2015 ASTRONOMICAL DATA ANALYSIS SYSTEMS AND SOFTWARE CONFERENCE

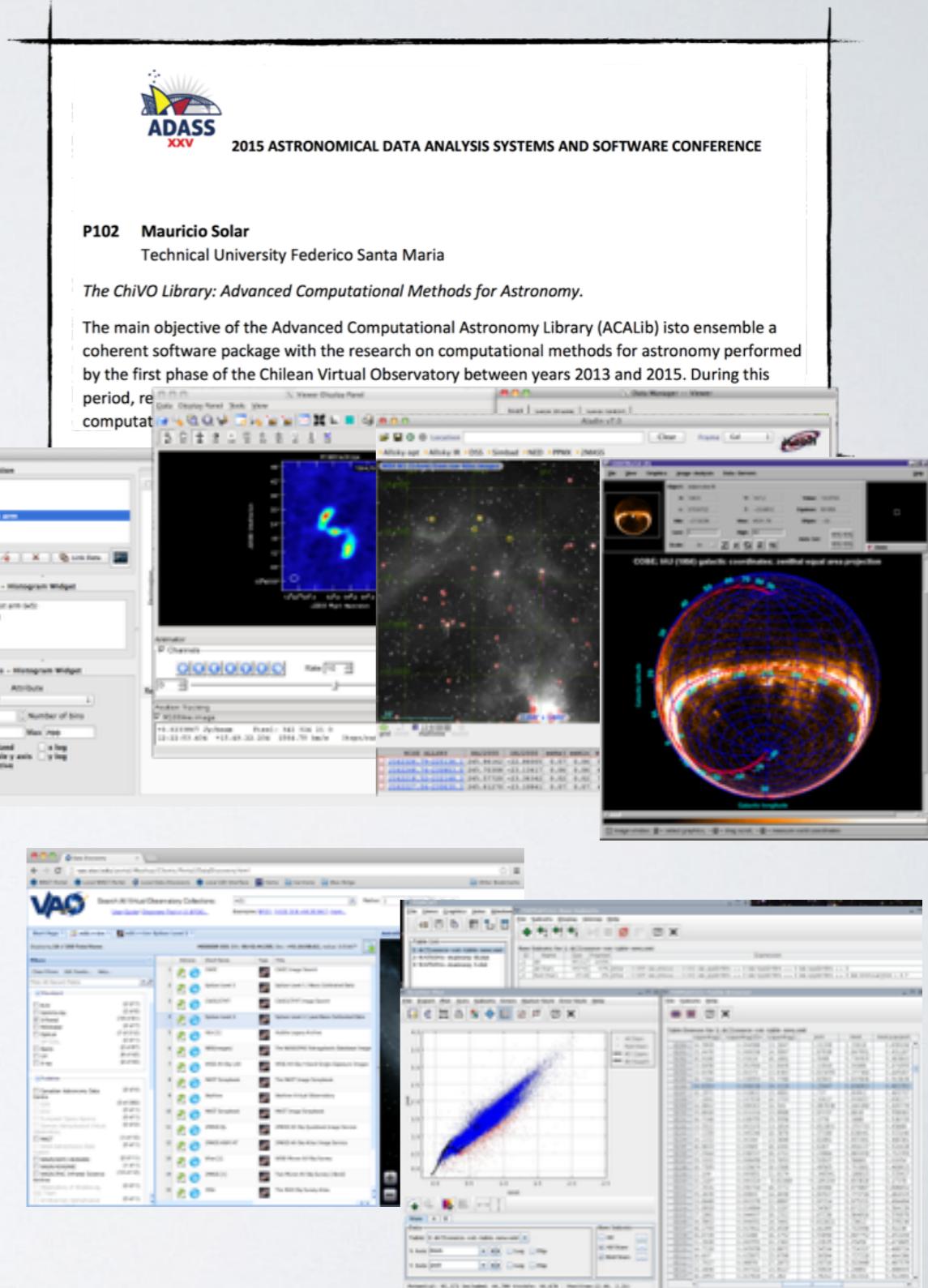
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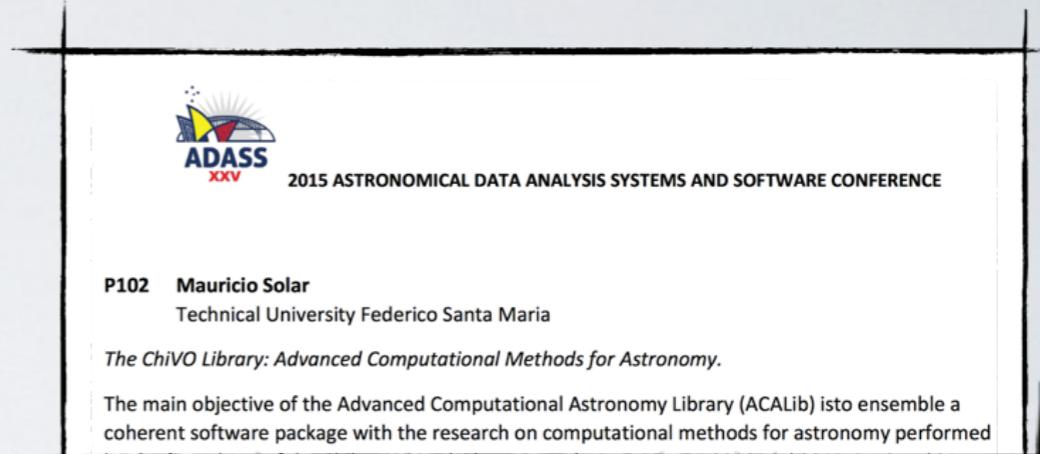
WHAT JOVIAL IS NOT...

- Yet another astronomical library
 - (we already try that last year)
- Yet another astronomical GUI
 - (too many good competitors)
- Yet another data discovery App
 - (other VOs are way ahead!)



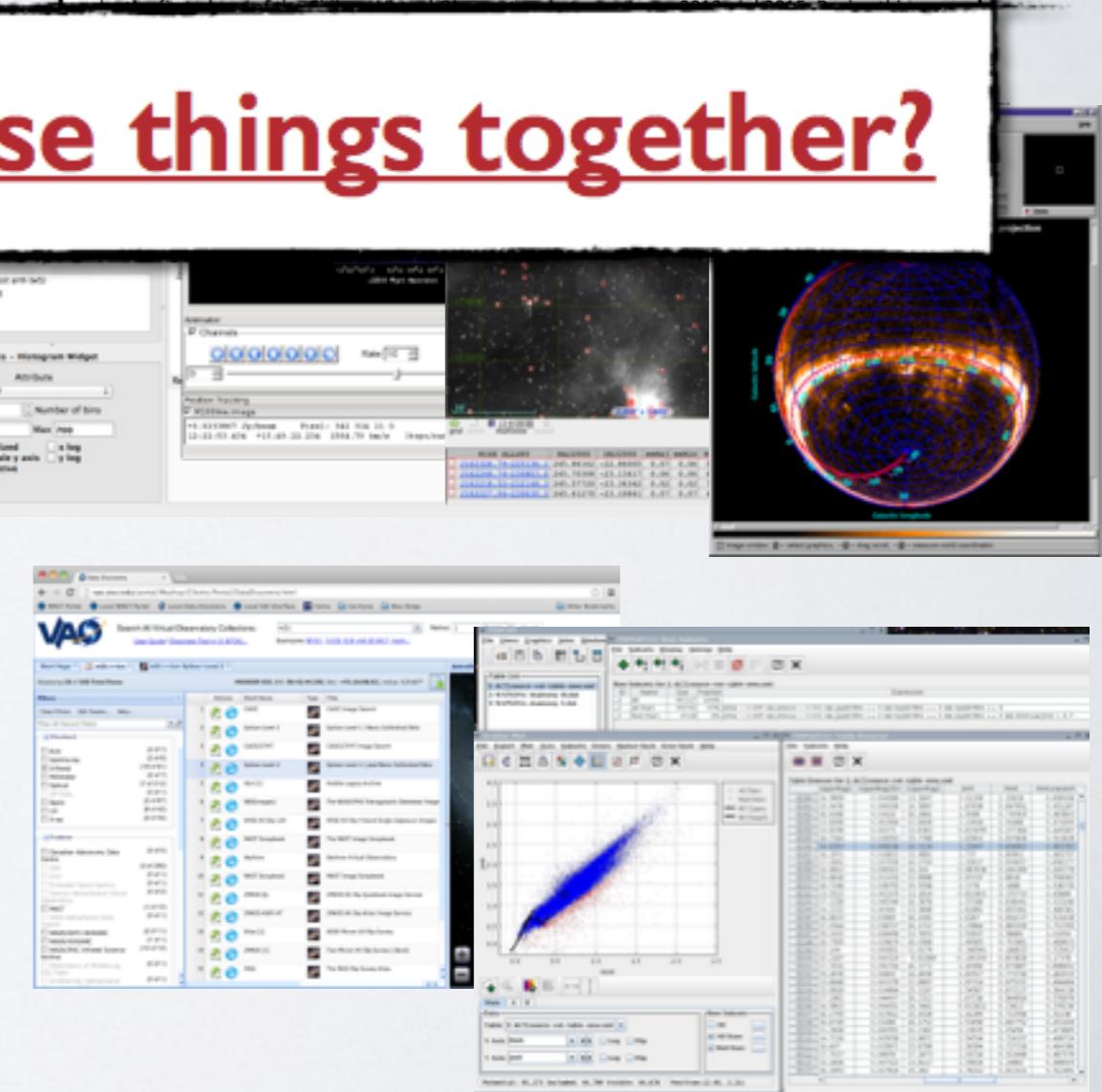
WHAT JOVIAL IS NOT...

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What if you can use all these things together?

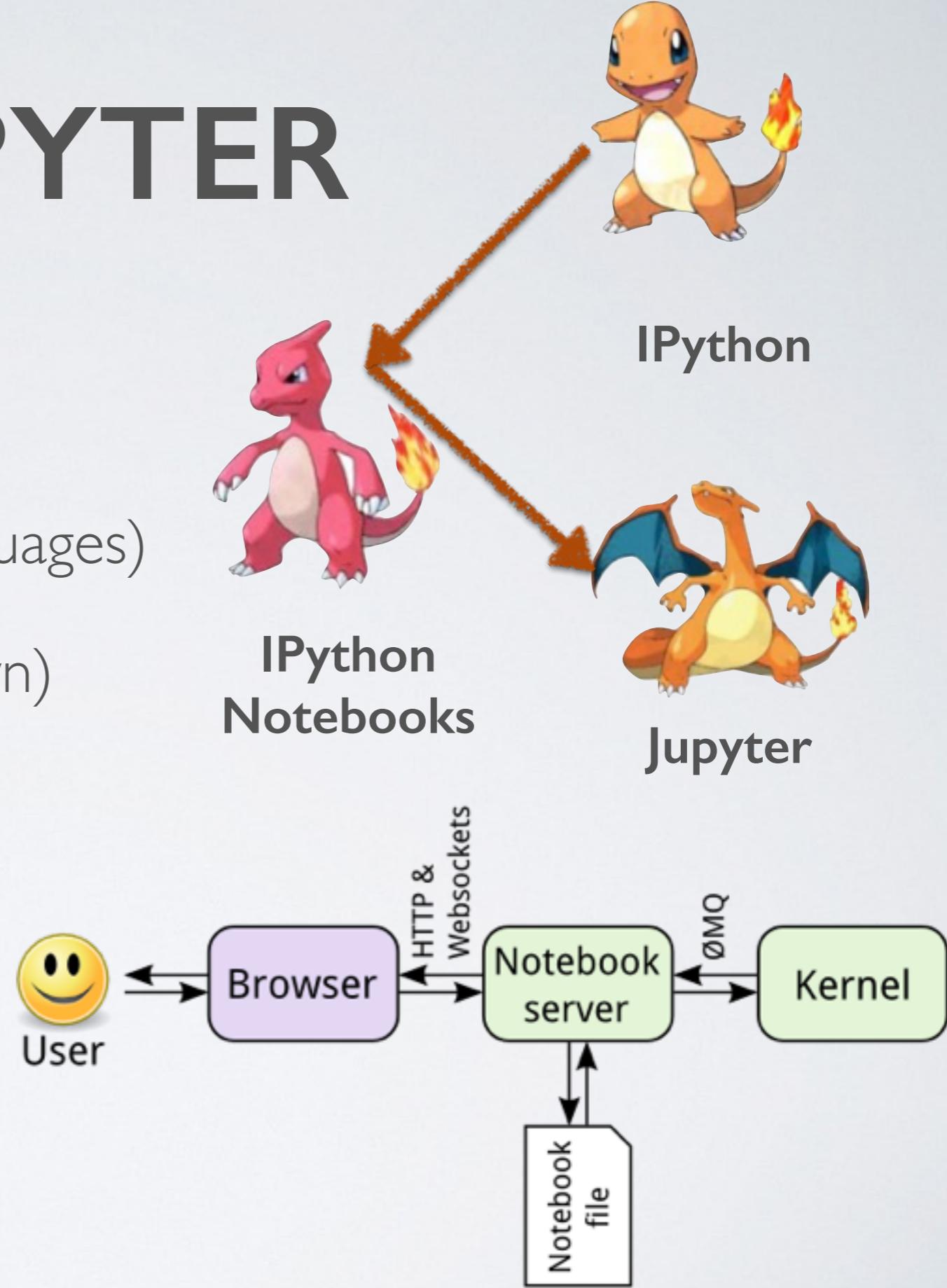
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JUPYTER

- Web-based application
 - Code snippets (several languages)
 - Markup language (markdown)
 - Interactivity
 - Inline visualisation
 - Autocompletion
 - Widgets





jupyter Welcome to P

File Edit View Insert Cell

jupyter

Welcome to the

This Notebook Server was created by:

WARNING

Don't rely on this server.

Your server is hosted there.

Run some Python code

To run the code below:

1. Click on the cell to select it
2. Press SHIFT+ENTER

A full tutorial for using the Jupyter Notebook is available at [http://jupyter.org](#).

In []: `import matplotlib inline`

```
import pandas as pd
import numpy as np
import matplotlib
```

jupyter Lorenz Differential Equations (autosaved)

File Edit View Insert Cell Kernel Help

Python 3

Exploring the Lorenz System

In this Notebook we explore the [Lorenz system](#) of differential equations:

$$\begin{aligned}\dot{x} &= \sigma(y - x) \\ \dot{y} &= \rho x - y - xz \\ \dot{z} &= -\beta z + xy\end{aligned}$$

This is one of the classic systems in non-linear differential equations. It exhibits a range of complex behaviors as the parameters (σ , β , ρ) are varied, including what are known as *chaotic* solutions. The system was originally developed as a simplified mathematical model for atmospheric convection in 1963.

In [7]: `interact(Lorenz, N=fixed(10), angle=(0.,360.),
 sigma=(0.0,50.0), beta=(0.,5), rho=(0.0,50.0));`

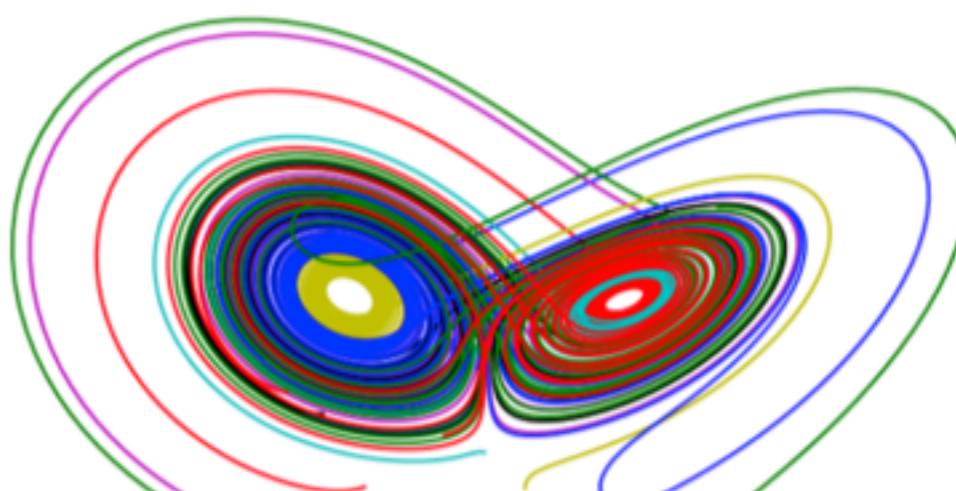
angle: 308.2

max_time: 12

σ : 10

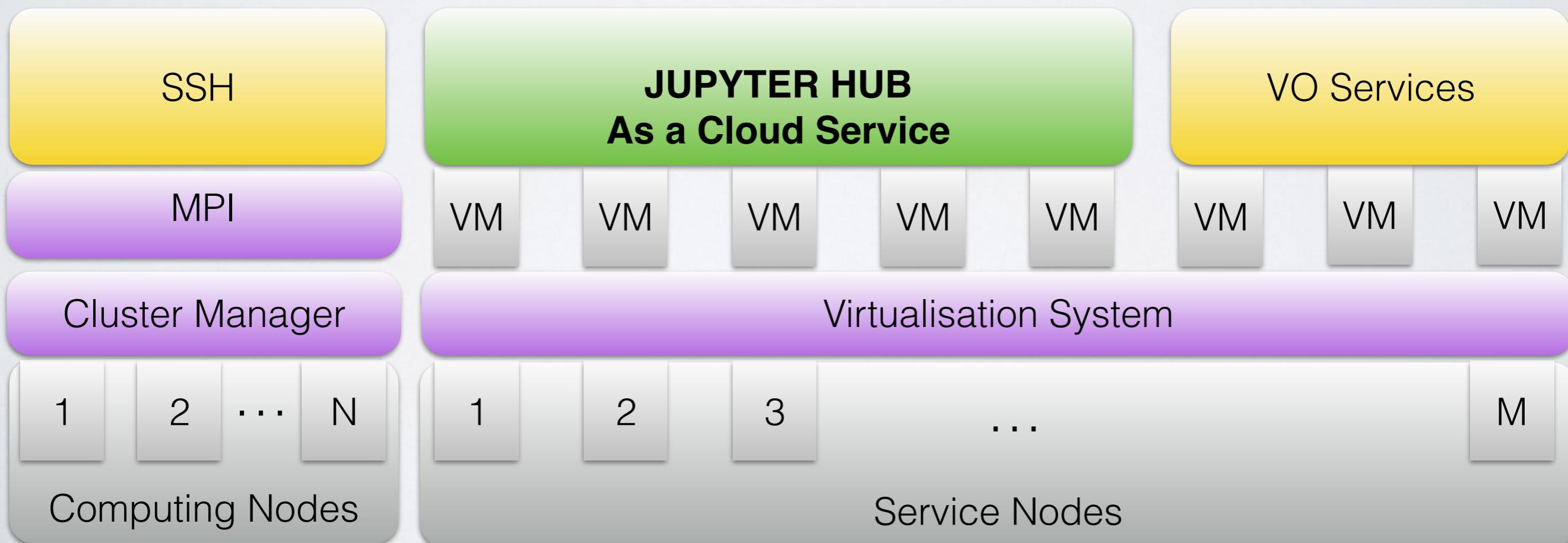
β : 2.6

ρ : 28



jupyter IN OUR DATA CENTER

- We have allocated a dedicated data centre for astronomy
 - We have already data access and batch processing capabilities
 - We want to make resources used for interactive data analysis



What we should put here?

JUPYTER HUB

What we should put here?



JUPYTER HUB

1. Python-based

2. Numpy-based

3. Matplotlib-based

4. Astropy-based

5. Notebook-aware

6. Advanced UI

EASY PEASY LIBRARIES

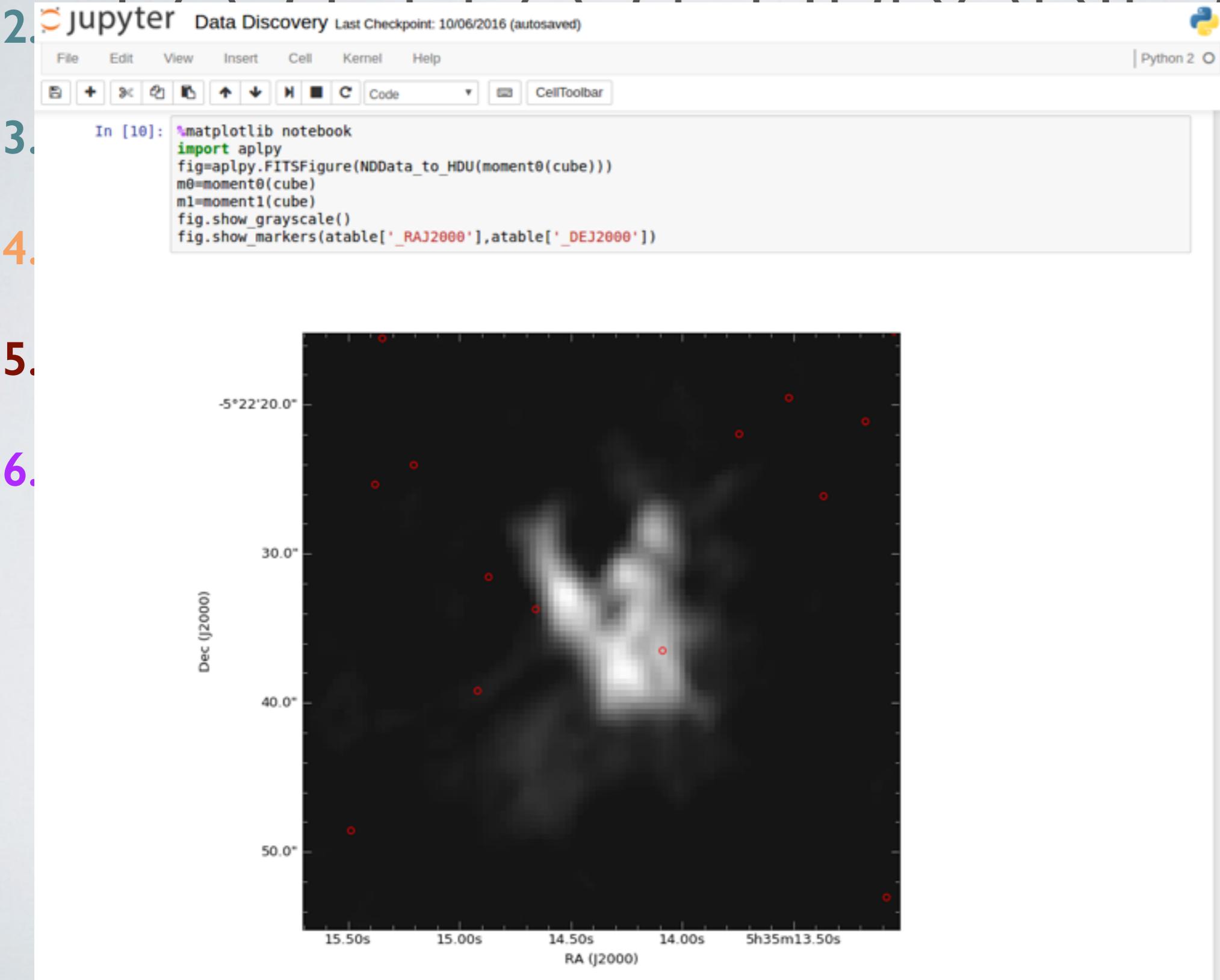


Astropy

PyData

JUPYTER HUB

I. Python-based FASy PFASy I IRRARIES



I. Python-based FAS

2. **jupyter Data Discovery**

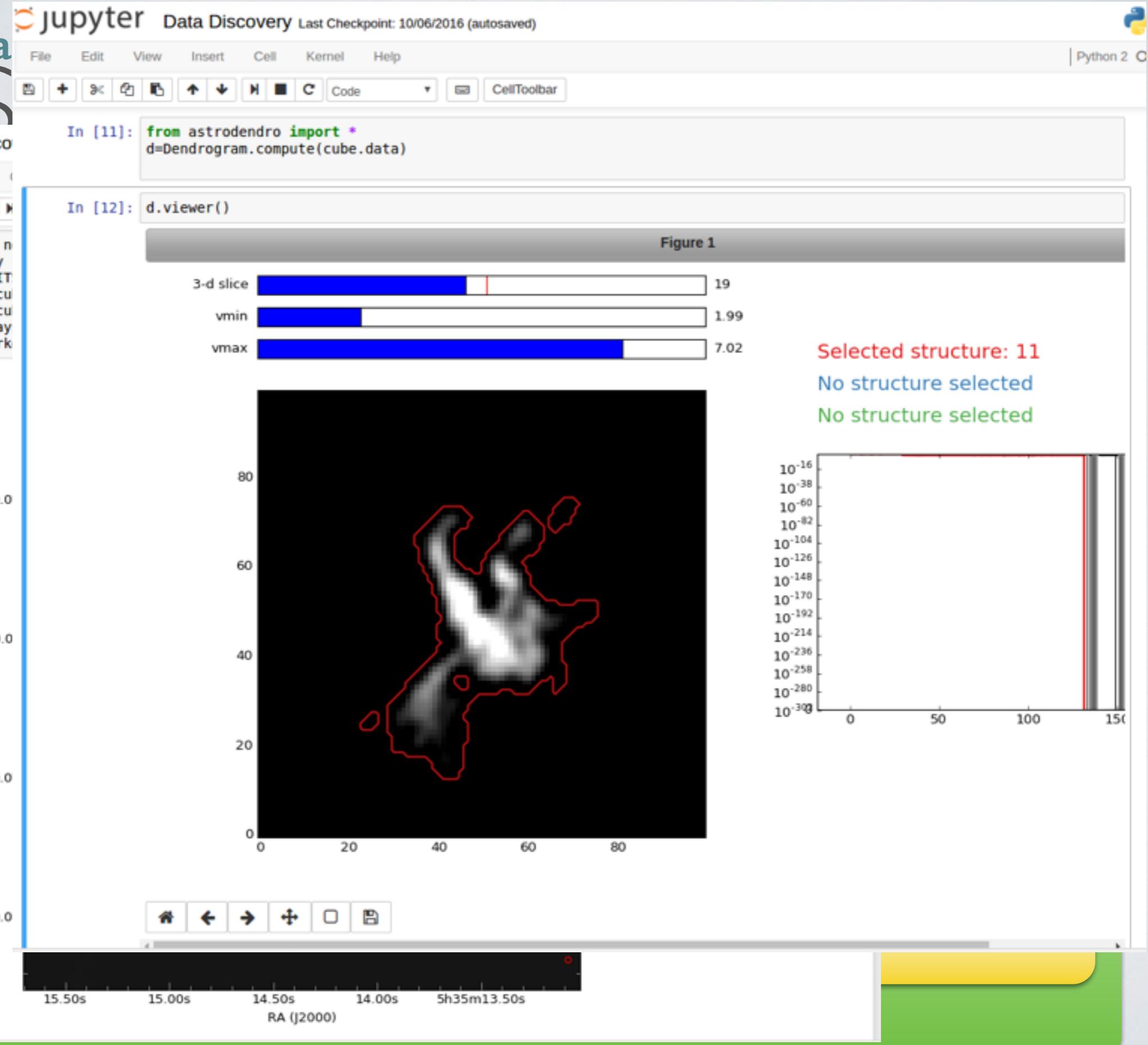
```
In [10]: %matplotlib notebook  
import aplpy  
fig=aplpy.FIT  
m0=moment0(cu  
m1=moment1(cu  
fig.show_gray  
fig.show_mark
```

3.

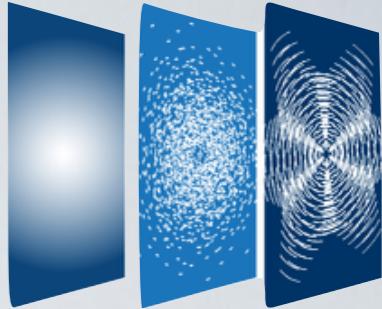
4.

5.

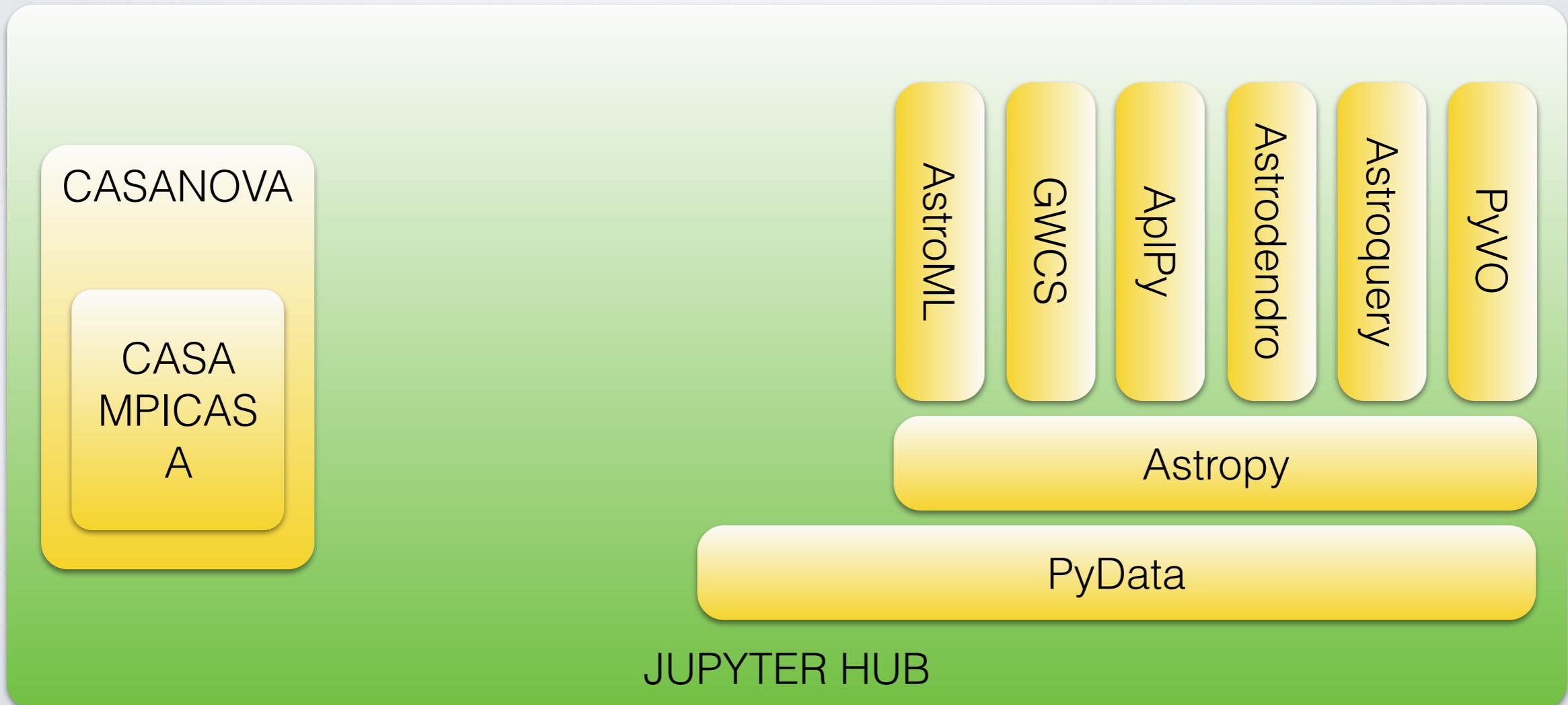
6.



INTEGRATING CASA



- CASANOVA patchelf strategy
 - Both CASA core and tasks work in JOVIAL
 - CASA 4.7 includes MPI support!



INTEGRATING CASA



- CA

jupyter First_Look_at_Imaging (autosaved) 

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 CellToolbar

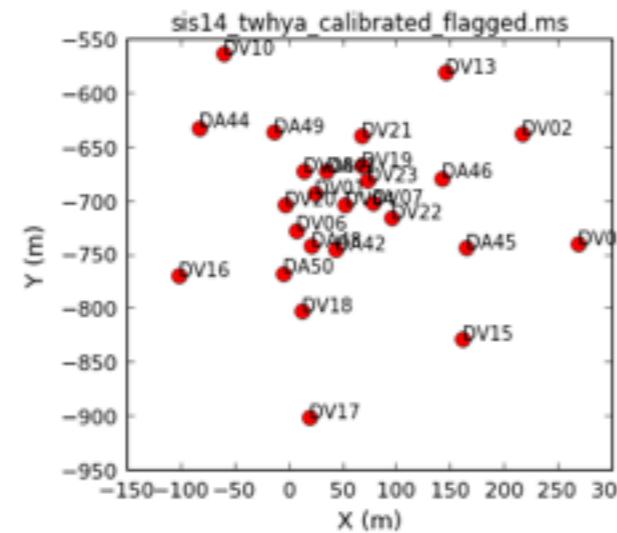
About the Sample Data: Continuum and N₂H⁺ in TW Hydra

The data for this example comes from ALMA Project 2011.0.00340.S, "Searching for H2D+ in the disk of TW Hya v1.5", for which the PI is Chunhua Qi. Part of the data for this project has been published in Qi et al. 2013. The original observation had three scientific objectives:

- Image the submm continuum structure in TW Hydra
 - Image the H2D+ line structure (rest frequency 372.42138 GHz)
 - Image the N2H+ line structure (rest frequency 372.67249 GHz)

The data used in our tutorial has already been calibrated. Furthermore, to make the data set more manageable, we have reduced it in size by averaging in time and frequency. Our goal will be to image the continuum emission and the N2H⁺ spectral line, which is bright and well suited for demonstrating the imaging techniques. The spectral window we will image covers 234.375 MHz in bandwidth, and contains 384 channels spaced by 610 kHz. The data includes observations from 21 of the ALMA 12-m main array antennas, observed during Early Science Cycle 0.

```
In [7]: plotants(vis='sis14_twhya_calibrated_flagged.ms')
```



Using tasks, and getting oriented with the data

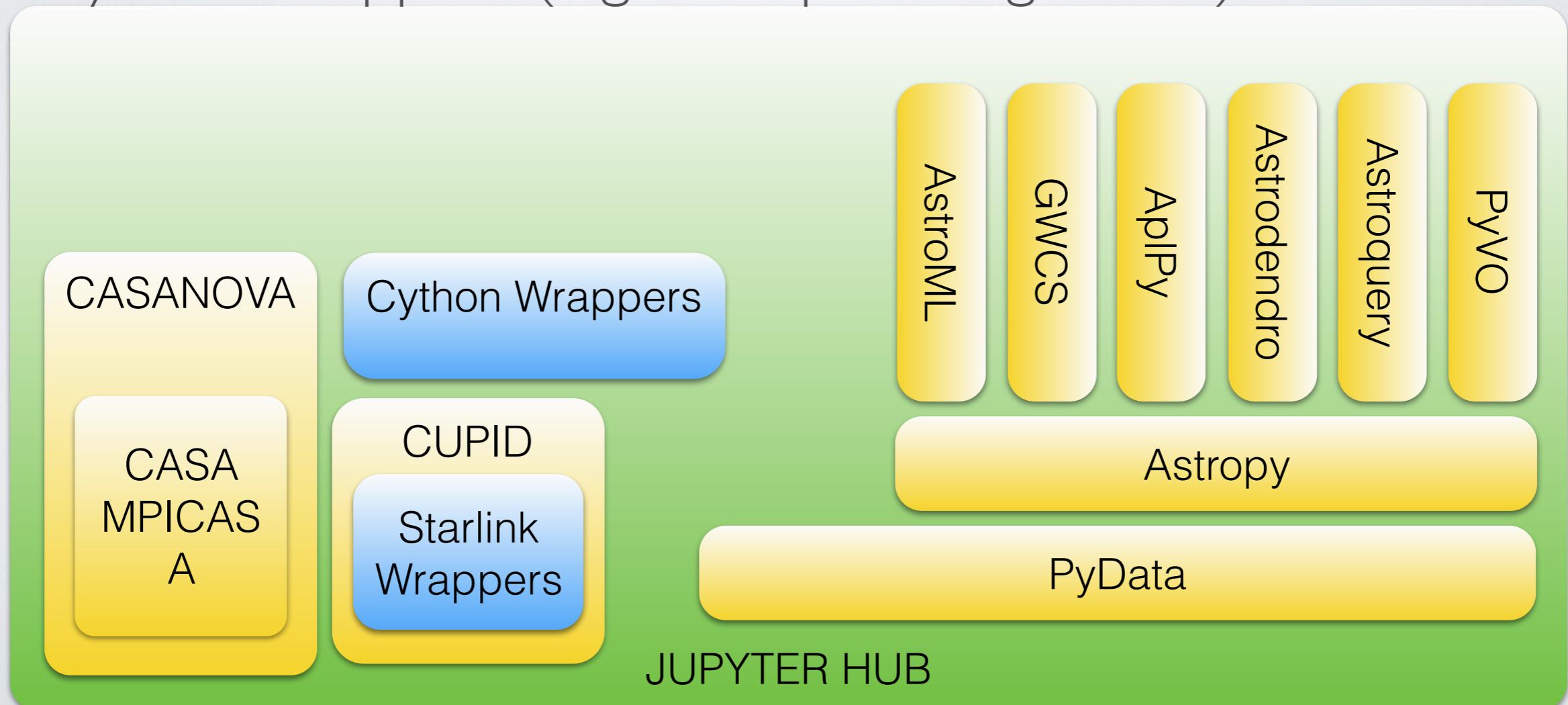
The first step in all data reduction with CASA is to examine the header information and data structure for the data set using the `listobs` task. In CASA, there are two ways to execute tasks. You can either set the parameters one-by-one and then instruct CASA to "go" when you're ready, or you can execute the task with a single command. For example, here is how you can use the first method:

To [8]: 18

INTEGRATING CUPID



- We wanted CUPID to run in Jupyter
 - CPython wrappers (e.g. AstKeyMap to PythonDictionary)
 - Cython wrappers (e.g. ClumpFind algorithm)





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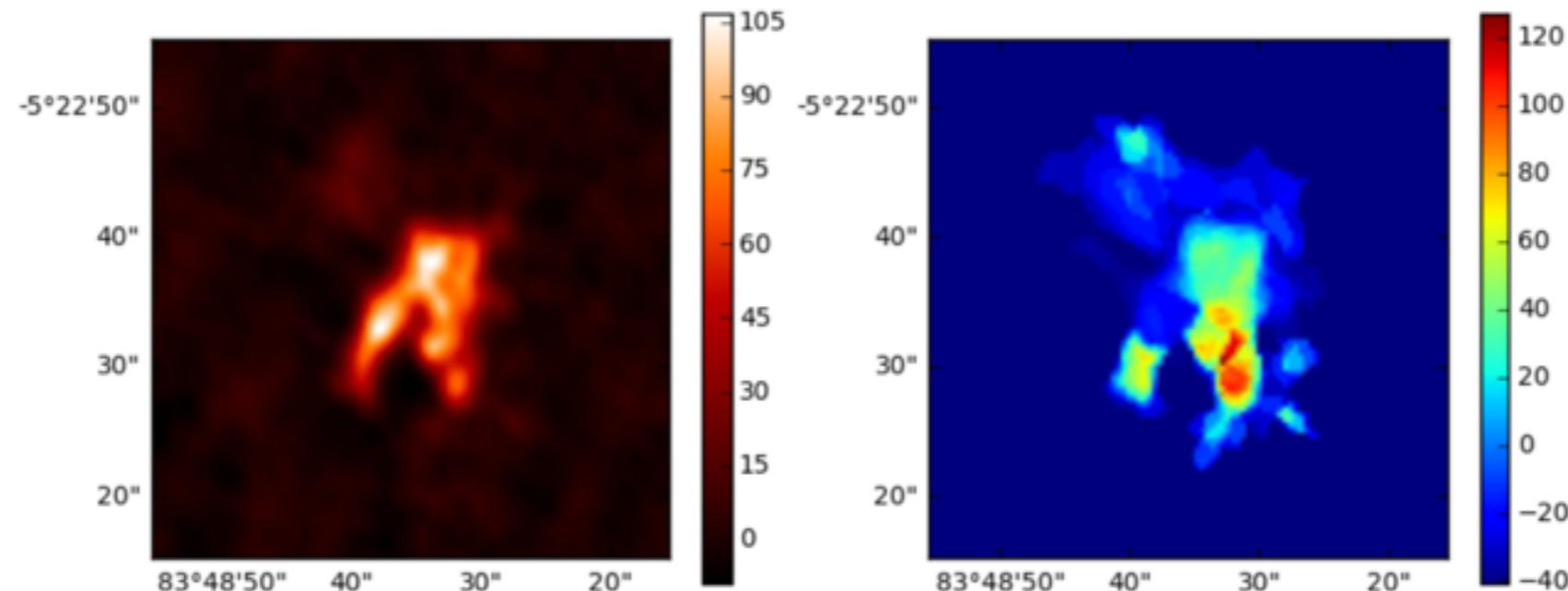
CellToolbar

Using Clumpfind

```
In [ ]: from acalib.algorithms import *
import matplotlib.pyplot as plt
cf          = ClumpFind()
caa,clumps = cf.run(orion)
```

```
In [9]: plt.figure(figsize=(10,4))
orion2D = moment0(orion)
plt.subplot(1,2,1,projection=orion2D.wcs)
plt.imshow(orion2D.data,cmap=plt.cm.gist_heat)
plt.colorbar()
plt.subplot(1,2,2,projection=orion2D.wcs)
plt.imshow(moment0(caa).data)
plt.colorbar()
```

```
Out[9]: <matplotlib.colorbar.Colorbar instance at 0x1122613f8>
```

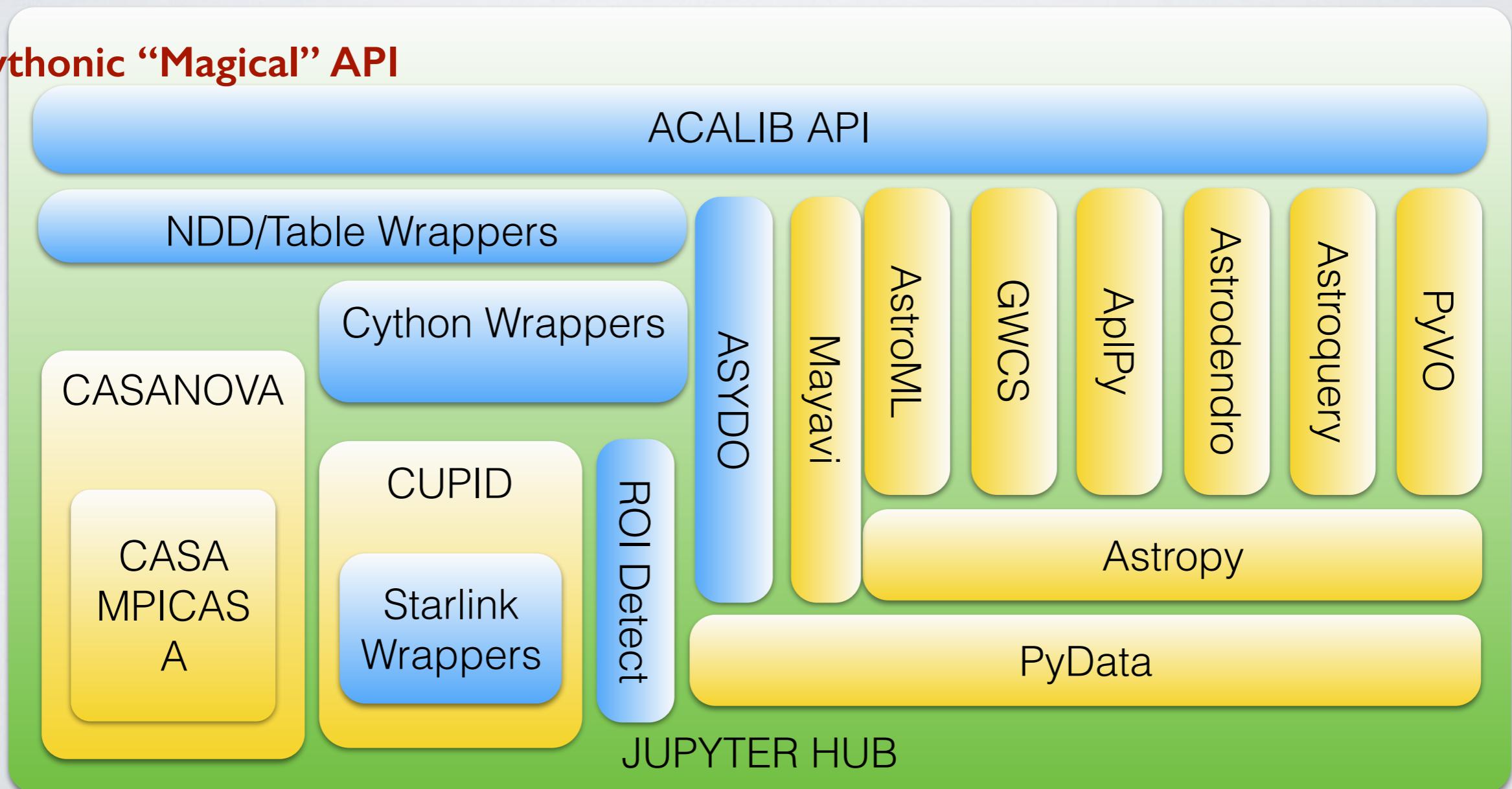


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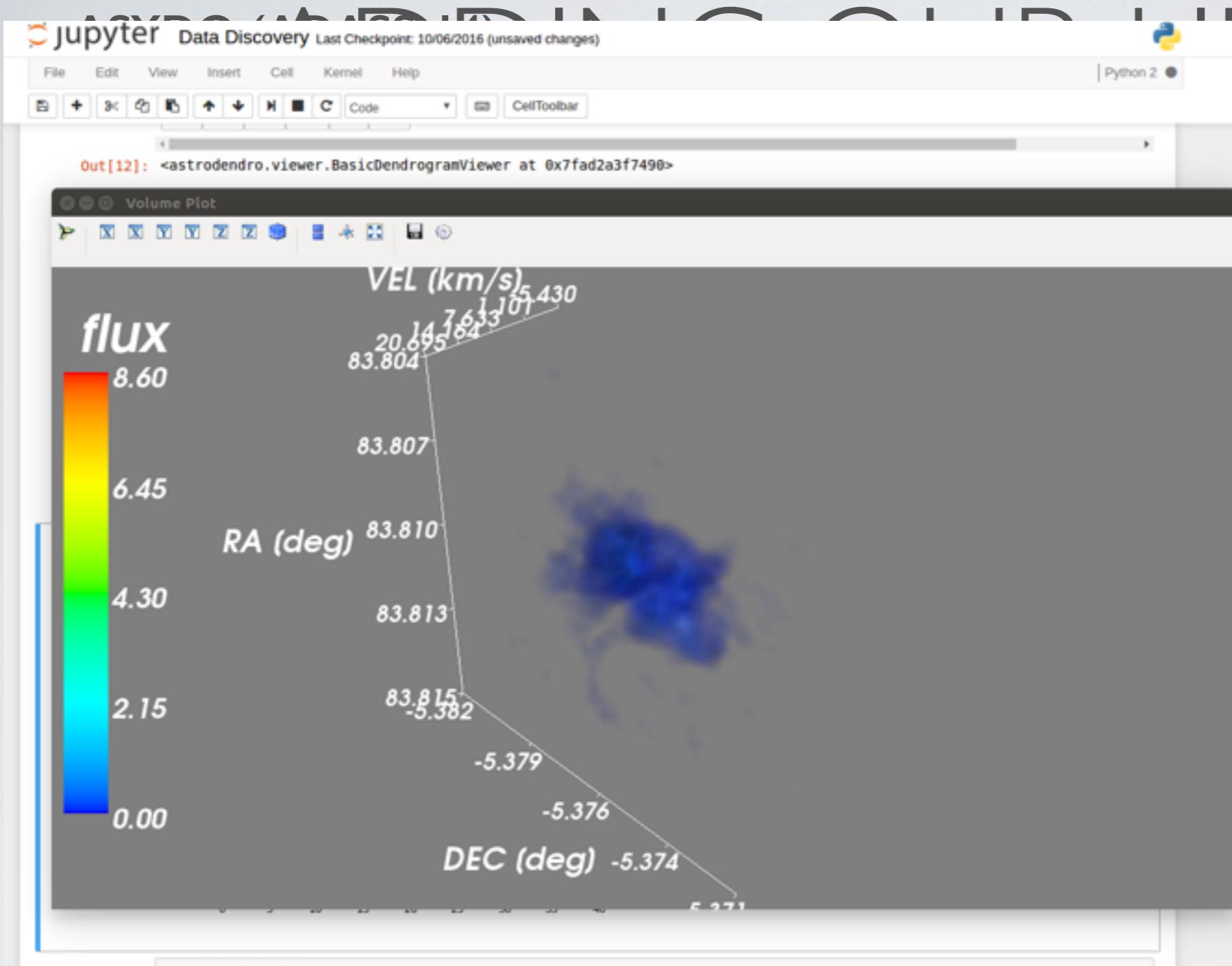
wrappers

ipyData

- ASYDO (ADASS-14)
- ROI Detect (A&C-16)
- Automatic Stacking
- BubbleClumps
- Volumetric Visualisation
- **Pythonic “Magical” API**



PyData LIBRARY



ASTRODENDRO LIBRARY

1

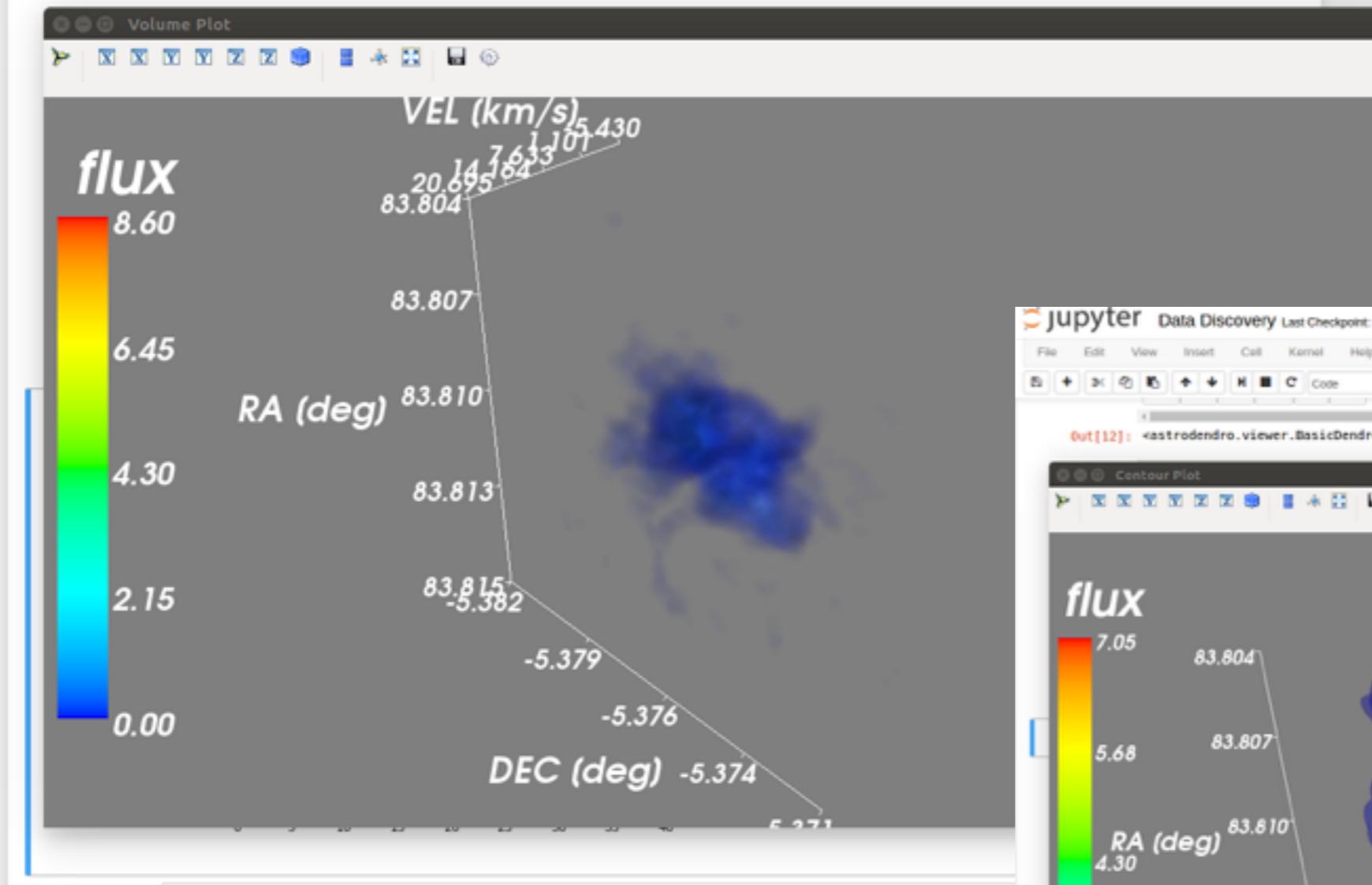
jupyter Data Discovery Last Checkpoint: 10/06/2016 (unsaved changes)

File Edit View Insert Cell Kernel Help

Code CellToolbar

Python 2

Out[12]: <astrodendro.viewer.BasicDendrogramViewer at 0x7fad2a3f7490>



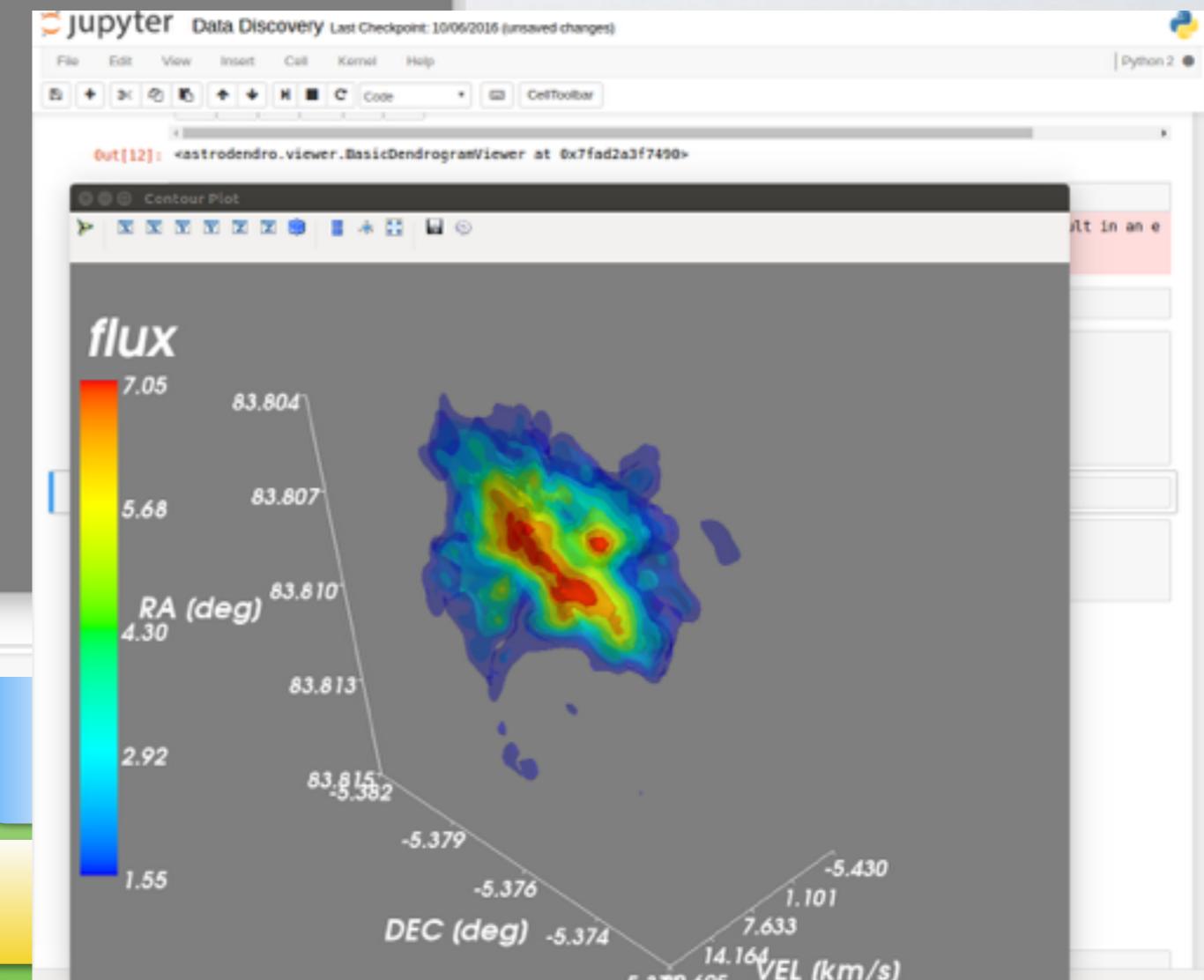
In [89]: %matplotlib inline

CASA
MPICAS
A

Starlink
Wrappers

ROI Detect

JUPYTER HUB



WORK IN PROGRESS

ACALIB API

NDD/Table Wrappers

ADMIT

CASANOVA

CASA

MPICAS

A

UWS

Cython Wrappers

More Slink

CUPID

Starlink
Wrappers

ASYDO

ROI Detect

Mayavi

AstroML

GWCS

ApIPy

Astrodendro

Astroquery

PyVO

Glue

Put your library here

Astropy

PyData

JUPYTER HUB

VoSpace

MPI

VM

VM

VM

VM

VM

VM

VM

VM

Cluster Manager

Ovirt

1

2

...

N

1

2

3

...

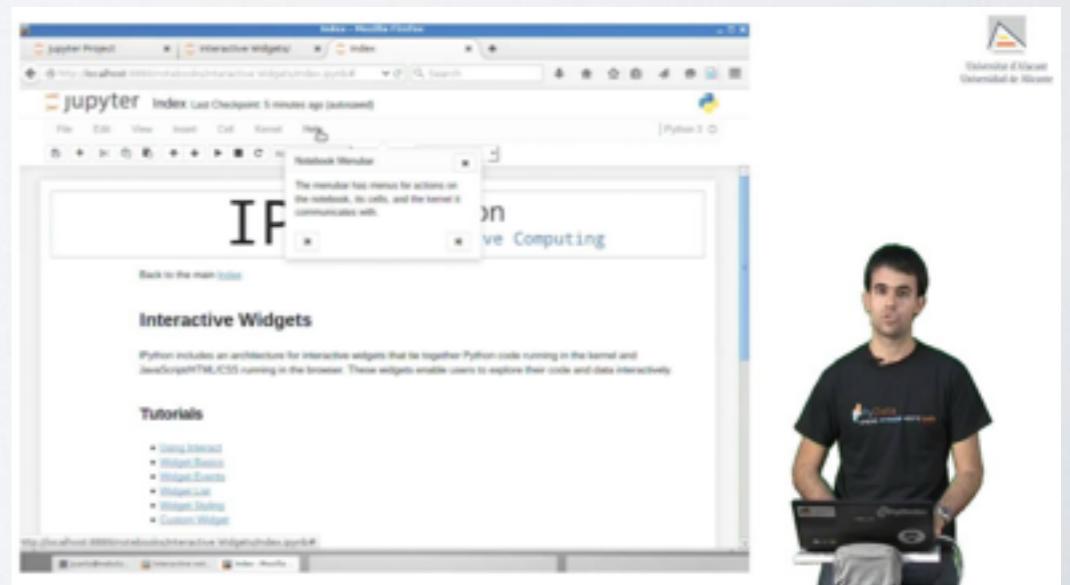
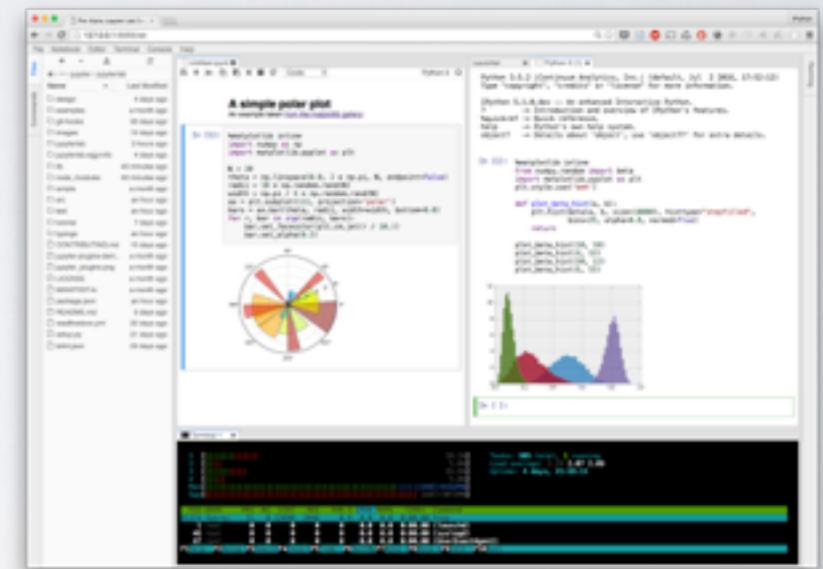
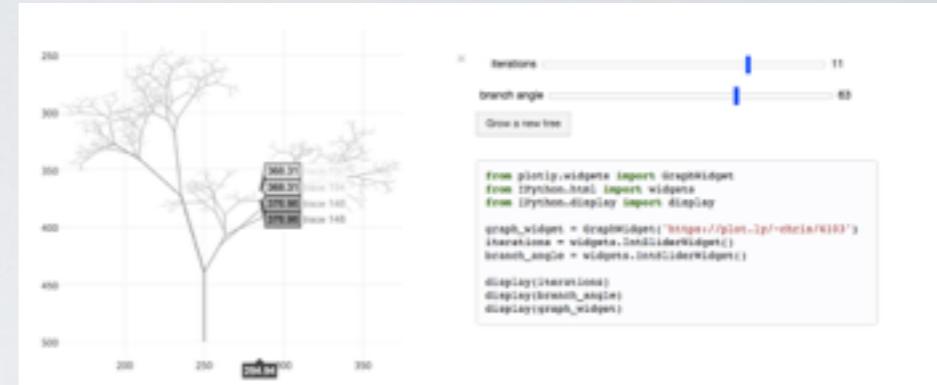
Computing Nodes

Service Nodes

M

FUTURE WORK

- Beta and production
- Interactivity (IPython widgets)
- Jolly (Jovial Local Laboratory)
- JupyterLab (next evolution)
- Tutorials for astronomers
- See you in ADASS'17 in Santiago!



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jupyter ASA CLOUD SERVICE

- **User Experience**

- No installation/upgrade
- Remote access/processing
- Flexible (code)
- Graphical UI
- Popular !

- **Opportunities**

- Abstraction of HPC
- User community
- Less data transfer
- Documented pipelines

JUPYTER HUB