Firefly, Python, JupyterLab

and the Science Platform

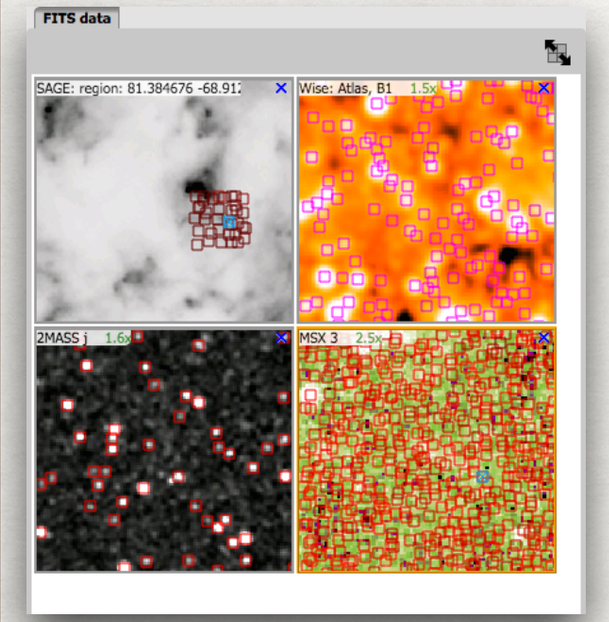
Science Platform

- Concept is catching fire in astronomy community
- Working definition of Science Platform in nutshell
  - Login to a Jupyter Lab/Hub environment
  - Appropriate software and APIs
  - Close data is archived
  - Processing close to the data
  - Usually with python.
- Our Goal:
  - Leverage out work with Firefly to make this environment more powerful

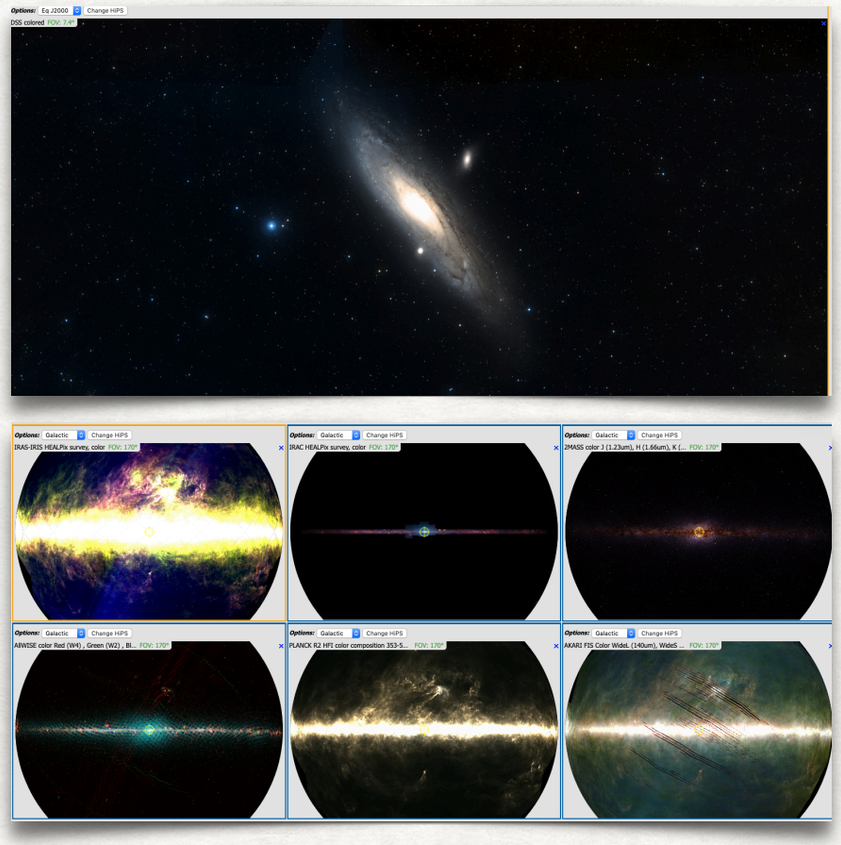
New Ways to Work

Firefly + Python + Jupyter Lab = Powerful Science Platform

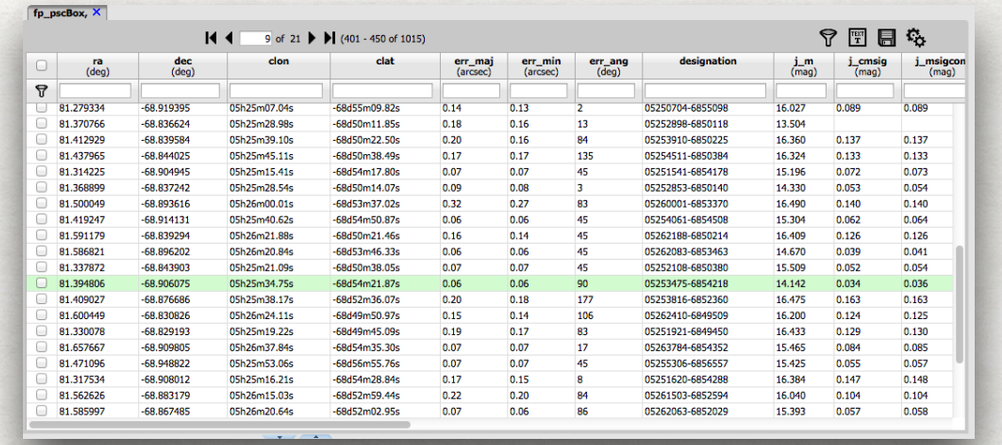
Firefly Components



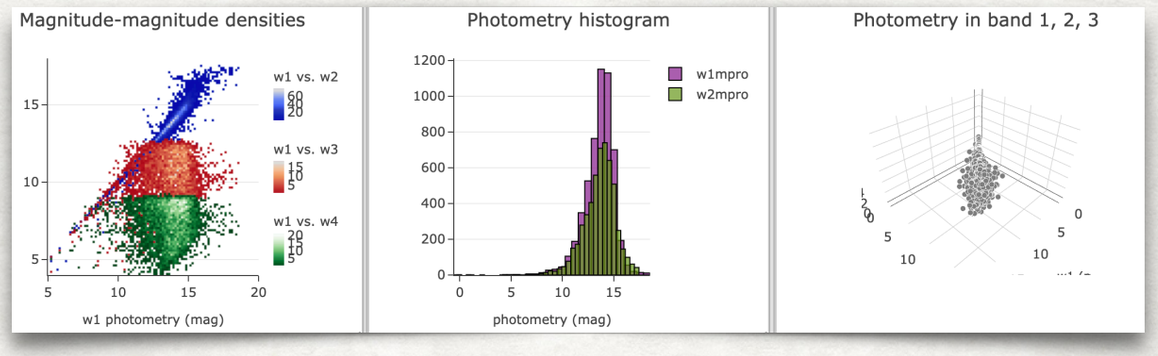
- WCS Readout
- Zoom
- Flip/ Rotate/ Crop
- Color / Stretch
- Grid
- Region
- Magnifier
- Distance tools
- Markers
- Fits Headers
- Crop

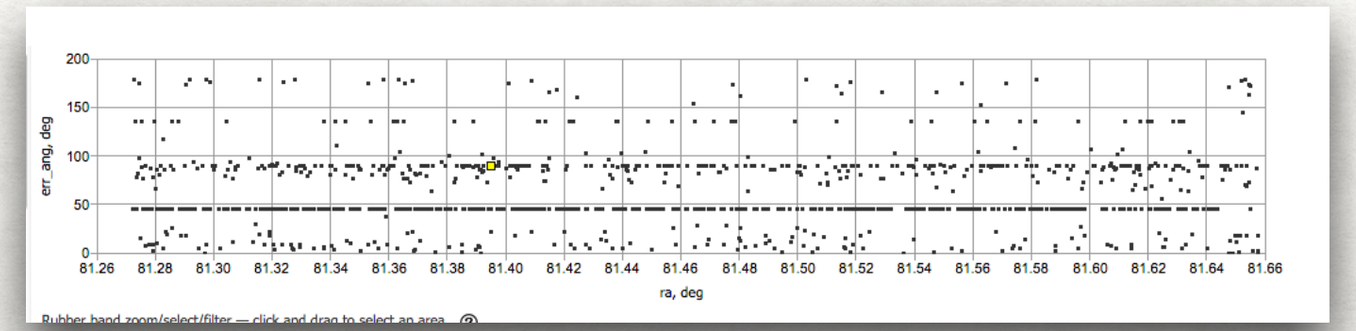


- Full HiPS Support
- MOC
- Tightly integrated
- Shares all FITS functions



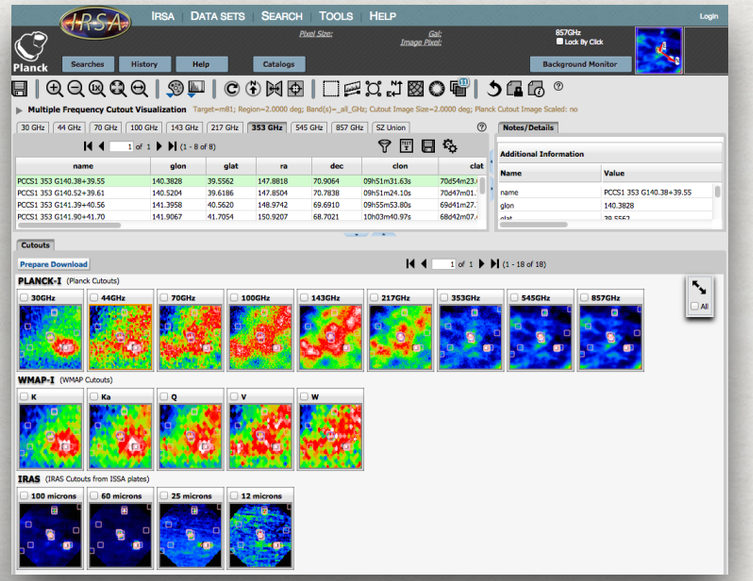
- Sort / Filter
- Column Controls
- Large tables, 10 Million+ rows
- Very fast response time
- brushing and linking

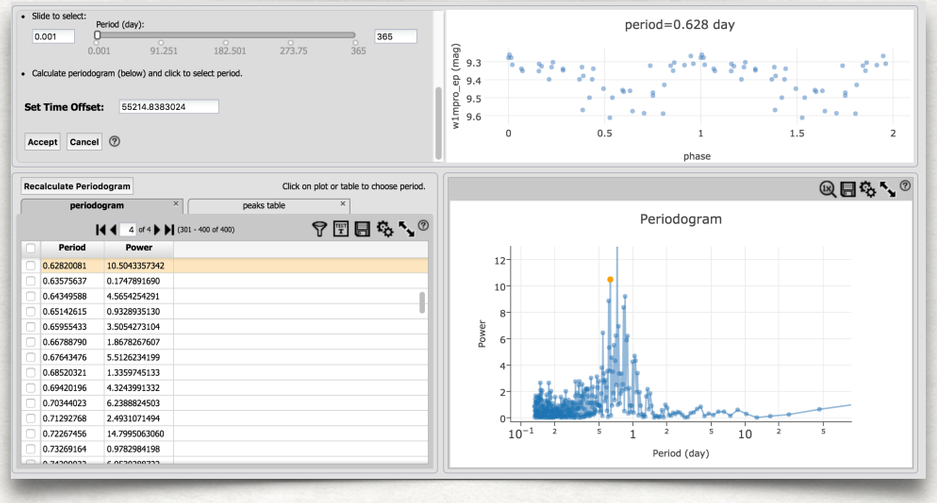


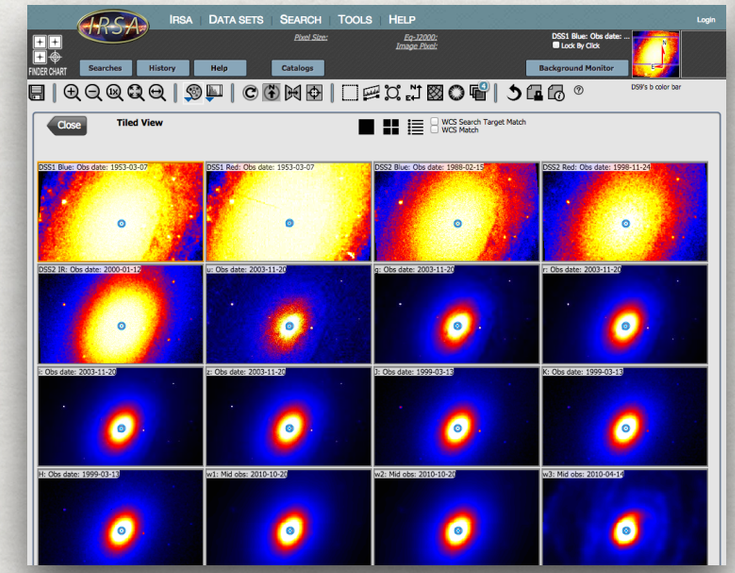


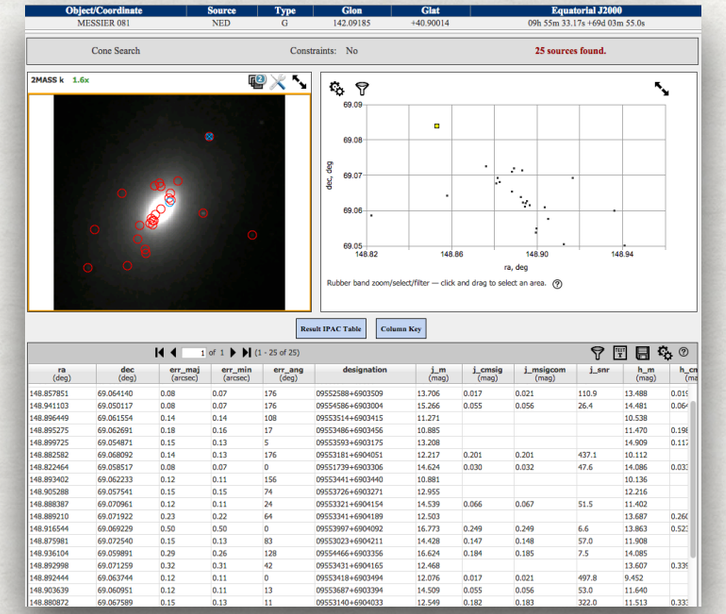
- Interactive
- Column math
- Zoom
- Filter

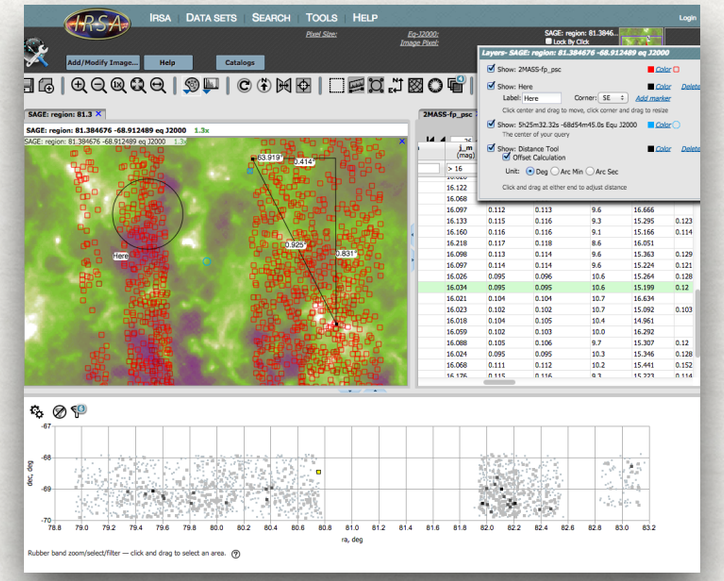
Firefly Library

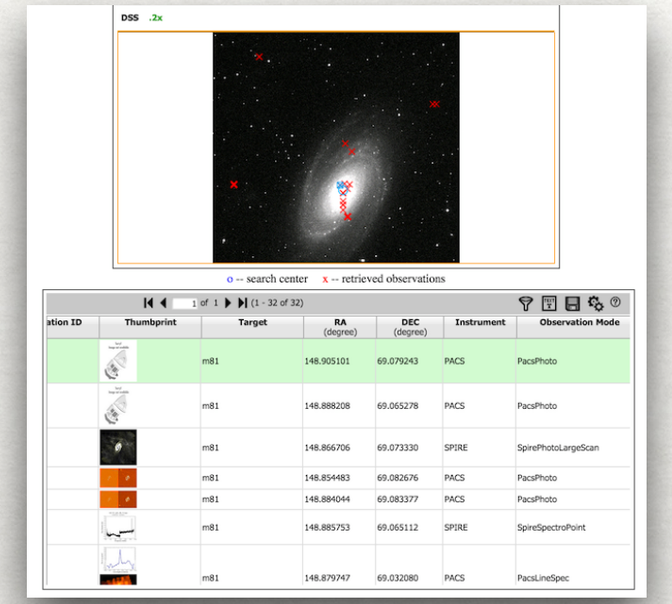


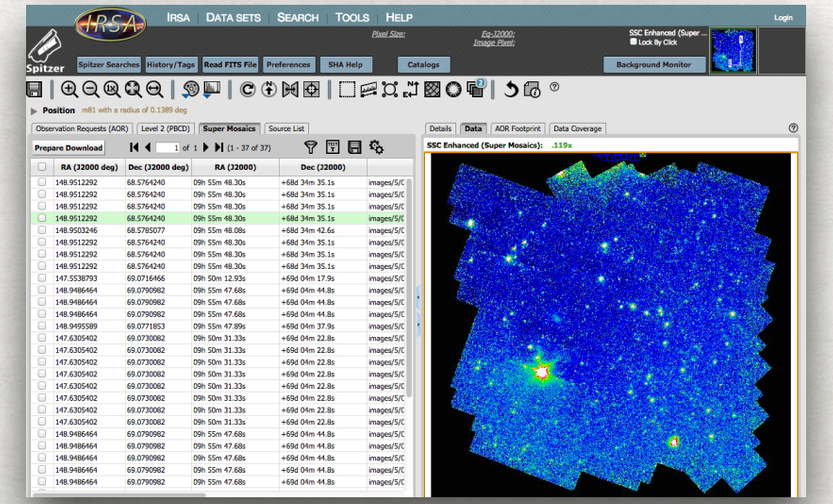


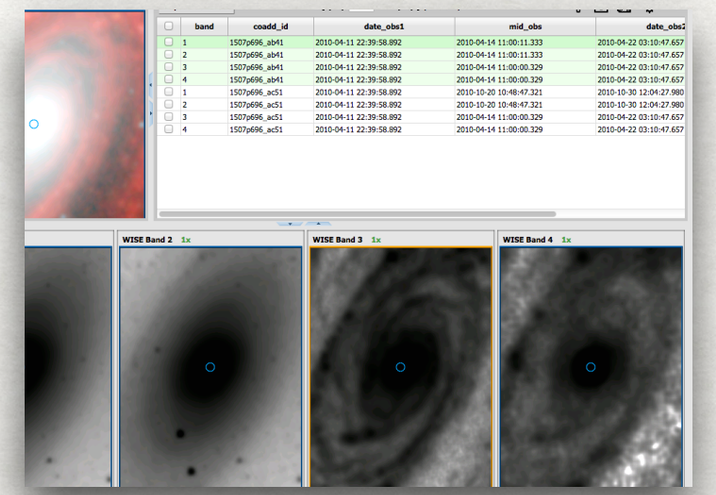












Firefly Archive Visualization Library

Code Overview

Frontend

- JavaScript
- Modern JS
  - ES6+, Modules

  - NPM

  - Webpack
- React/Redux

- Converted from GWT
  - 2015 - 2016

Backend

- Java
- Tomcat

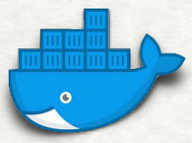
- Scalable
  - Multiple instances
- JSON to Client
  - GET, POST, Websocket
- Docker and Kubernetes

Frontend & Backend:

~245K Lines of code

Open Source and Releases

- GitHub
  - https://github.com/Caltech-IPAC/firefly
- Releases
  - More Formal Process
  - Builds on Docker
  - Release Notes
  - CCB - Yearly Roadmap
- Dockerized
  - Start firefly with one command
  - Tag for each release plus nightly



Ways to Use Firefly

1. Stand alone
   - Install and Run
2. Library for building Web Applications
   - Most Advanced: Work at the React/ Redux level
   - Many IRSA application built from Firefly
3. JavaScript API
   - Firefly Widgets in a Web page
4. Remote API
   - Control a Firefly Application

➡ Key to interfacing with Python

➡ Start application & control it from Python

Remote API

- Firefly architecture is designed around the command pattern
- Each command tells the system to do something
  - Plot image
  - Zoom Image
  - Rotate Image
- Firefly can also listen for commands over channel
- HTTP communication and Web Sockets
- Commands sent as HTTP request

Remote API

Another Context

Send an Action

Network (http)

JSON Data

```
Action: {
  type : String,
  payload :
  {data}
}
```

Firefly

Web Server

Action

Network (Web socket)

Firefly

WebApp in Browser

Examples:

- Load a FITS Image
- Load a Table
- Show a Chart
- Sort a table
- Show HiPS

Python Binding

Connecting Python to Firefly

- https://github.com/Caltech-IPAC/firefly_client
- `pip install firefly_client`
- Connects to the firefly server via URL
- Hides network connectivity
- Implements API to control Firefly from Python
- Can do this in Jupyter Notebook or Lab

```
from firefly_client import FireflyClient
fc = FireflyClient.make_client('firefly url')
fc.launch_browser()
fc.show_fits(URL='some url')
handle = fc.upload_file(a_file)
fc.show_table(handle)
```

```
In [1]: from firefly_client import FireflyClient
   ...: fc = FireflyClient.make_client('127.0.0.1:8080/firefly')
```

```
In [1]: from firefly_client import FireflyClient
   ...: fc = FireflyClient.make_client('127.0.0.1:8080/firefly')
   ...: fc.launch_browser()
   ...: fc.show_fits(URL='http://web.ipac.caltech.edu/staff/roby/demo/wise-m51-band2.fits')
```

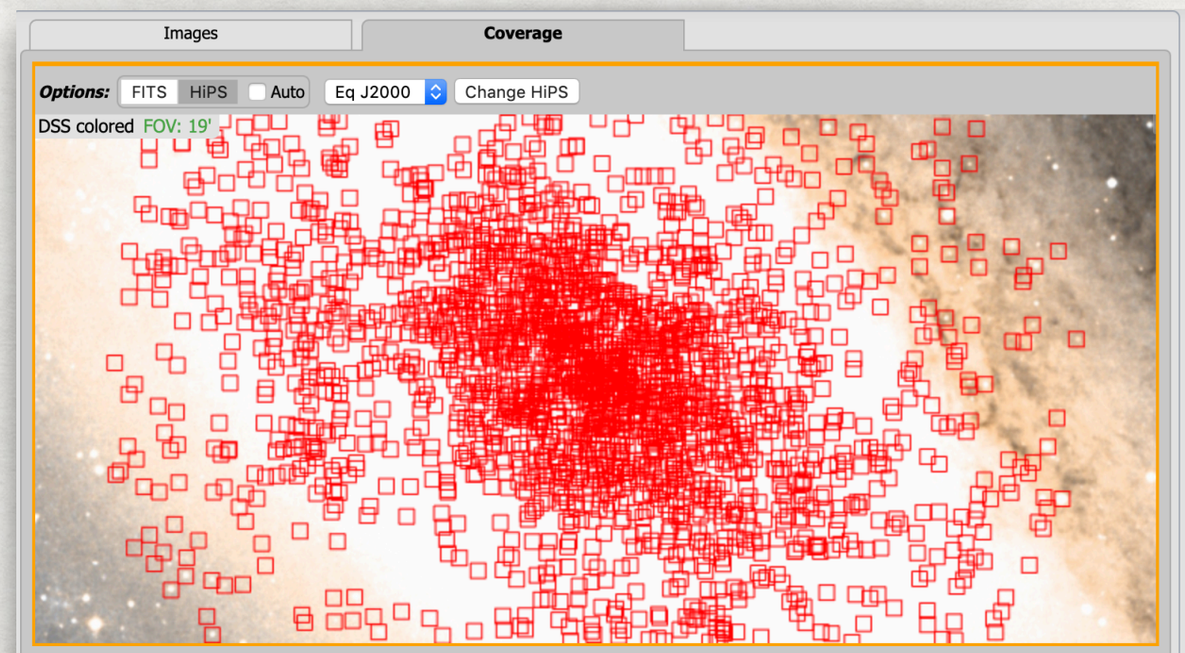
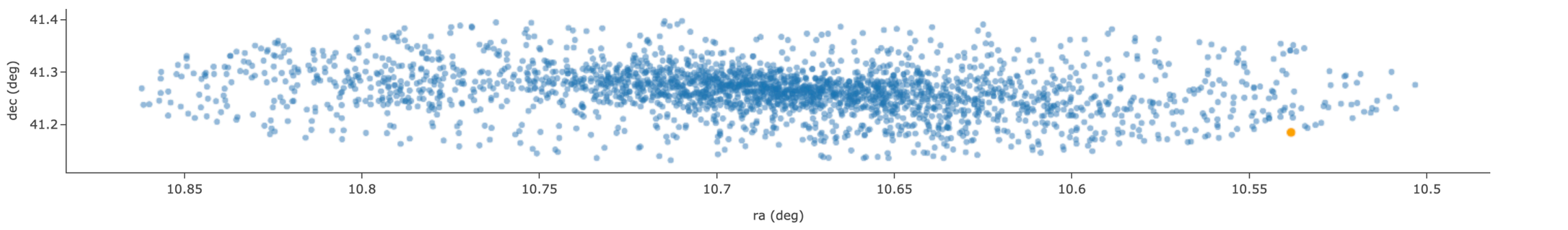


Table-1 ×

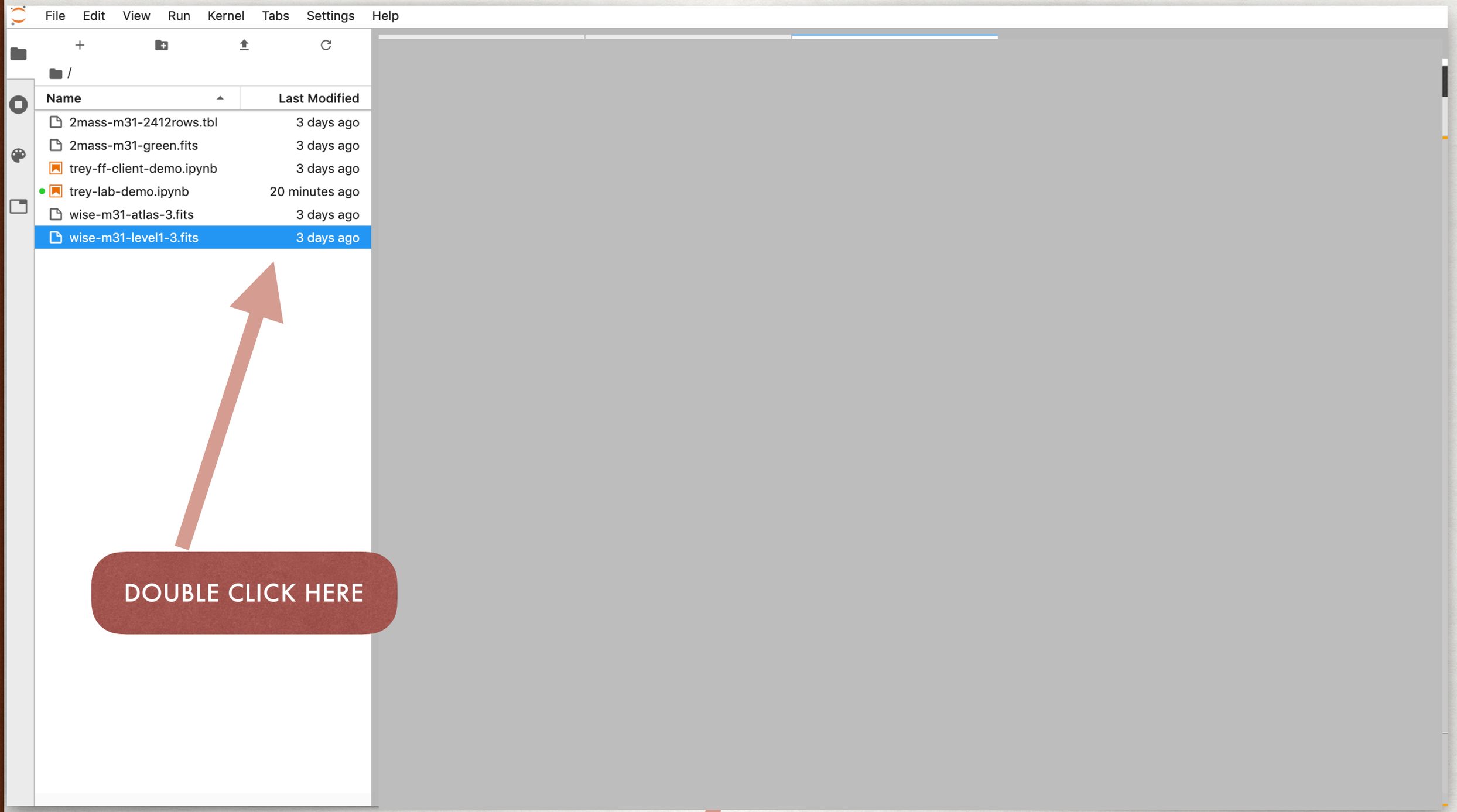
1 of 25 (1 - 100 of 2,412)

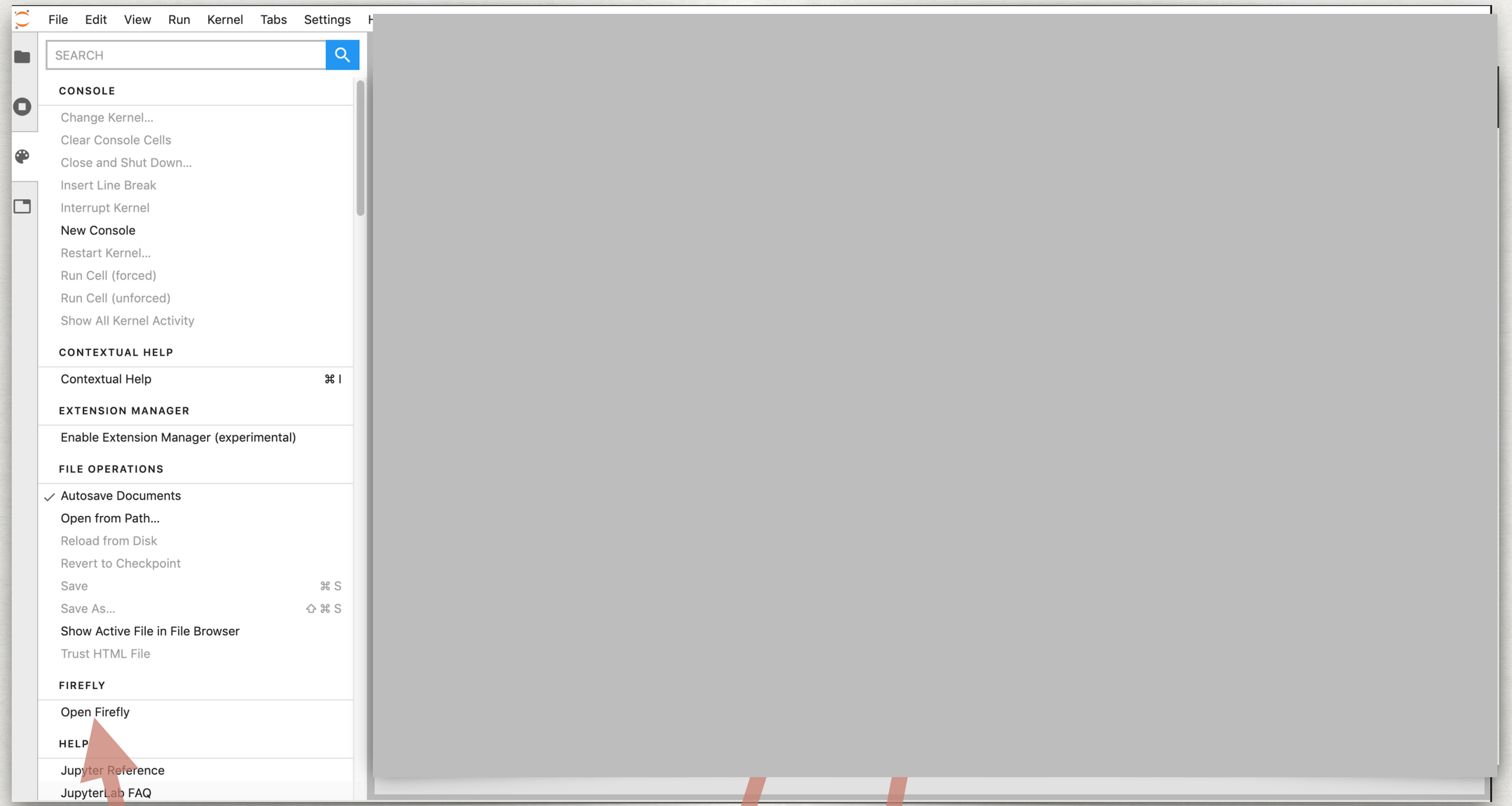
ra	dec	clon	clat	err_maj	err_min	err_ang	designation	j_m
10.538223	41.185280	00h42m09.17s	41d11m07.01s	0.07	0.06	0	00420917+4111070	11.995
10.838491	41.246212	00h43m21.24s	41d14m46.36s	0.30	0.29	10	00432123+4114463	16.620
10.637667	41.181141	00h42m33.04s	41d10m52.11s	0.17	0.15	7	00423304+4110521	16.109
10.611032	41.151657	00h42m26.65s	41d09m05.97s	0.20	0.18	23	00422664+4109059	16.392
10.620758	41.341530	00h42m28.98s	41d20m29.51s	0.12	0.11	0	00422898+4120295	16.102
10.830915	41.312050	00h43m19.42s	41d18m43.38s	0.20	0.20	17	00431941+4118433	16.362
10.685197	41.247932	00h42m44.45s	41d14m52.56s	0.14	0.13	79	00424444+4114525	15.694
10.774212	41.308735	00h43m05.81s	41d18m31.45s	0.26	0.23	1	00430581+4118314	16.433
10.702413	41.319077	00h42m48.58s	41d19m08.68s	0.29	0.26	86	00424857+4119086	15.166
10.712607	41.317383	00h42m51.03s	41d19m02.58s	0.30	0.24	11	00425102+4119025	15.292
10.734037	41.224167	00h42m56.17s	41d13m27.00s	0.09	0.08	93	00425616+4113270	15.000
10.575720	41.180710	00h42m18.17s	41d10m50.56s	0.24	0.22	178	00421817+4110505	16.694
10.745465	41.260391	00h42m58.91s	41d15m37.41s	0.24	0.23	111	00425891+4115374	14.824
10.561621	41.302677	00h42m14.79s	41d18m09.64s	0.12	0.11	17	00421478+4118096	15.977
10.644463	41.240864	00h42m34.67s	41d14m27.11s	0.23	0.20	88	00423467+4114271	14.455
10.607822	41.235588	00h42m25.88s	41d14m08.12s	0.26	0.25	1	00422587+4114081	16.542
10.670102	41.235668	00h42m40.82s	41d14m08.40s	0.15	0.14	85	00424082+4114084	14.106
10.697447	41.275070	00h42m47.39s	41d16m30.25s	0.13	0.13	101	00424738+4116302	12.019



Jupyter Lab

- Jupyter Lab is Extendable
- Using Various Firefly API we have written extensions
  - https://github.com/Caltech-IPAC/jupyter_firefly_extensions
- Firefly will run in a Jupyter Lab tab
- Extensions:
  - FITS File Opener
  - Visualization Extensions using FireflyClient
  - Lab Widgets
- Result: A very integrated system


File
Edit
View
Run
Kernel
Tabs
Settings
Help
/
Name
Last Modified
2mass-m31-2412rows.tbl
3 days ago
2mass-m31-green.fits
3 days ago
trey-ff-client-demo.ipynb
3 days ago
trey-lab-demo.ipynb
20 minutes ago
wise-m31-atlas-3.fits
3 days ago
wise-m31-level1-3.fits
3 days ago
DOUBLE CLICK HERE
TO SHOW THIS



CLICK HERE

TO BRING UP FIREFLY
IN A LAB TAB

```
# Add table in cell 'main'.
# 'main' is the cell id currently supported by Firefly for element type 'tables'
# this cell is shown at row = 0, col = 4 with width = 2, height = 2

r = fc.add_cell(0, 2, 4, 2, 'tables', 'main')

if r['success']:

    fc.show_table(tbl_id='wiseCatTbl', title='WISE catalog',
                  target_search_info={'catalogProject': 'WISE', 'catalog': 'allwise_p3as_psd',
                                      'position': target, 'SearchMethod': 'Cone', 'radius': 1200},
                  options={'removable': True, 'showUnits': Fa
```

```
# Add first chart - scatter (plot.ly direct plot)
# in cell 0, 0, 2, 2,
viewer_id = 'newChartContainer'
r = fc.add_cell(0, 0, 2, 2,'xyPlots', viewer_id)

if r['success']:
    trace1 = {
        'tbl_id': 'wiseCatTbl',
        'x': "tables::w1mpro-w2mpro",
        'y': "tables::w2mpro-w3mpro",
        'mode': 'markers',
        'type': 'scatter',
        'marker': {'size': 4}}
    trace_data=[trace1]

    layout_s = {'title': 'Color-Color',
                'xaxis': {'title': 'w1mpro-w2mpro (mag)'}, 'y
    fc.show_chart(group_id=viewer_id, layout=layout_s, data=t

# Add second chart - heatmap  (plot.ly direct plot)
# in cell 2, 0, 2, 3
viewer_id = 'heatMapContainer'
r = fc.add_cell(2, 0, 2, 3,'xyPlots', viewer_id)

if r['success']:
    dataHM = [
                {
                    'type': 'fireflyHeatmap',
                    'name': 'w1 vs. w2',
                    'tbl_id': 'wiseCatTbl',
                    'x': "tables::w1mpro",
                    'y': "tables::w2mpro",
                    'colorscale': 'Blues'
                },
                {
                    'type': 'fireflyHeatmap',
                    'name': 'w1 vs. w3',
                    'tbl_id': 'wiseCatTbl',
                    'x': "tables::w1mpro",
                    'y': "tables::w3mpro",
                    'colorscale': 'Reds',
                    'reversescale': True
                },
                {
                    'type': 'fireflyHeatmap',
                    'name': 'w1 vs. w4',
                    'tbl_id': 'wiseCatTbl',
                    'x': "tables::w1mpro",
                    'y': "tables::w4mpro",
                    'colorscale': 'Greens'
                }]

layout_hm = {'title': 'Magnitude-magnitude densities',
             'xaxis': {'title': 'w1 photometry (mag)'},
             'firefly': {'xaxis': {'min': 5, 'max': 20},
```

NOTEBOOK

PRODUCES THIS DISPLAY

Launcher | wise-m31-atlas-3.fits | wise-m31-level1-3.fit | Firefly: slate-1 | trey-lab-demo.ipynb | Firefly: slateClient-1-

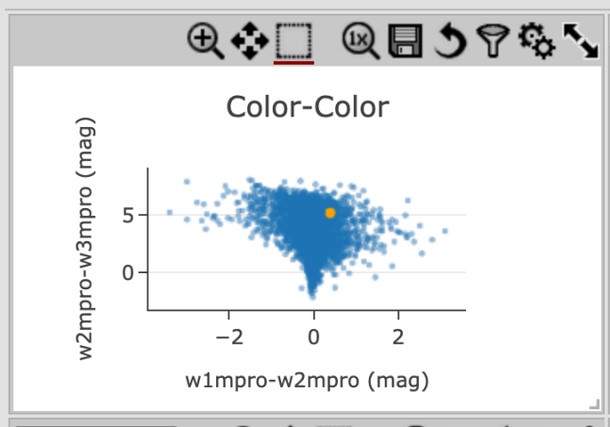
Firefly

Pixel Size:

EQ-J2000:
Image Pixel:

Lock by click

Images | Catalogs | Charts | Upload

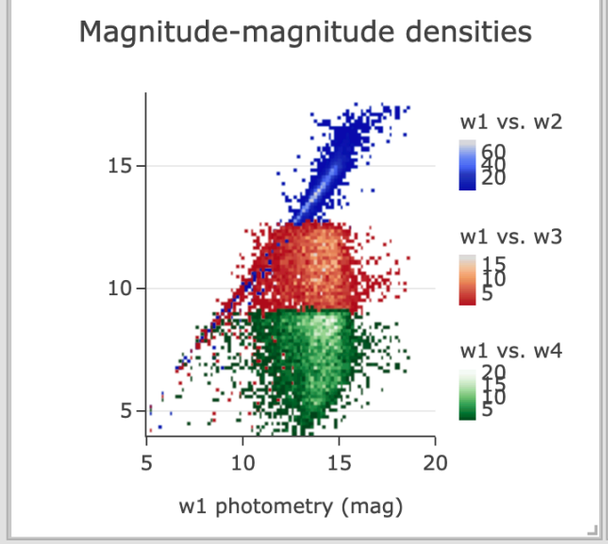


WISE catalog

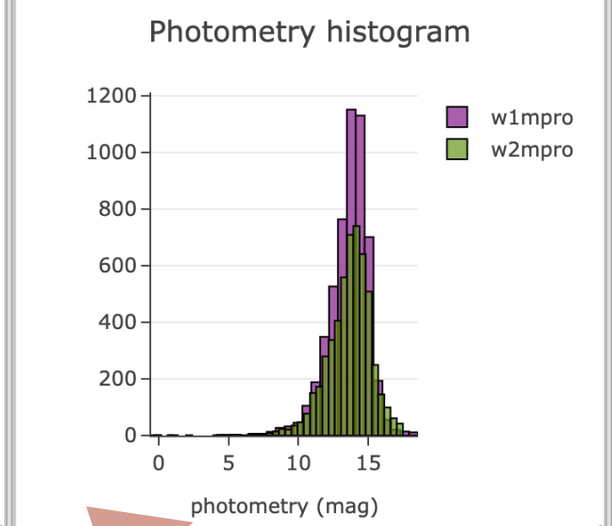
1 of 54 (1 - 100 of 5,348)

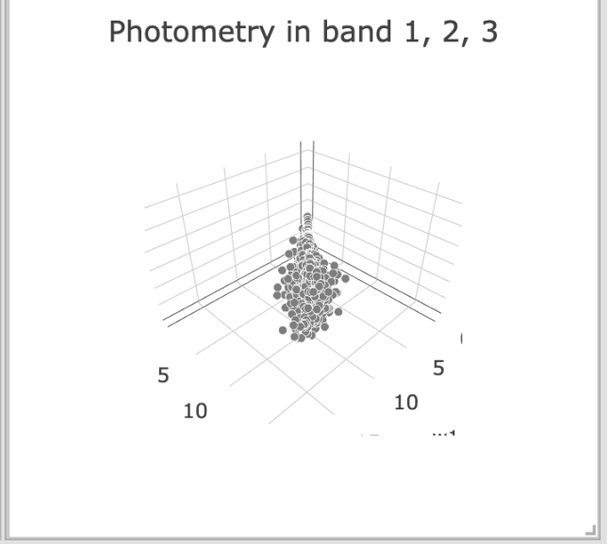
designation	ra	dec	clon	clat	sigra	sigdec	sigradec
J025002.71+604401.4	42.5113126	60.7337440	02h50m02.72s	60d44m01.48s	0.1171	0.1272	-0.03
J024957.41+604341.4	42.4892372	60.7281732	02h49m57.42s	60d43m41.42s	0.0749	0.0768	-0.01
J025002.90+604412.0	42.5120997	60.7366803	02h50m02.90s	60d44m12.05s	0.0748	0.0745	-0.01
J024958.46+604407.2	42.4935984	60.7353471	02h49m58.46s	60d44m07.25s	0.1392	0.1479	0.04
J024956.02+604339.2	42.4834403	60.7275800	02h49m56.03s	60d43m39.29s	0.1081	0.1193	-0.04
J025005.79+604407.1	42.5241496	60.7353258	02h50m05.80s	60d44m07.17s	0.0384	0.0362	0.00
J024955.50+604353.2	42.4812708	60.7314650	02h49m55.50s	60d43m53.27s	0.0668	0.0662	-0.01
J025007.85+604335.4	42.5327410	60.7265044	02h50m07.86s	60d43m35.42s	0.1928	0.1978	-0.05

w1 vs. w4



w2mpro





Lesson learned: Jupyter Lab Extension

What went well

- Concept completely worked - Jupyter Lab is very flexible
- Lab uses modern JS build tools such as NPM and Webpack
  - Works with Firefly well.
- Lab did not conflict with Firefly - impressive for a complex tool
- We discovered issues with Firefly
  - Good way to test and improve the API
- We went though an upgrade cycle- is was fairly painless

Lesson learned: Jupyter Lab Extension

Challenges

- Very little extension documentation
- Difficult to do some fairly straight forward extension development
  - Look at examples (are the example correct?)
  - Get on Gitter, ask questions and hope someone will answer
  - Go thought the Lab code
- Extension development went slow

Firefly / Python / Jupyter Lab

- A lot of potential
- Fits nicely into a Web based Science Platform
- Opportunity to design many custom visualizations
- Much, much more we can do


ipac