ALMA archive capability

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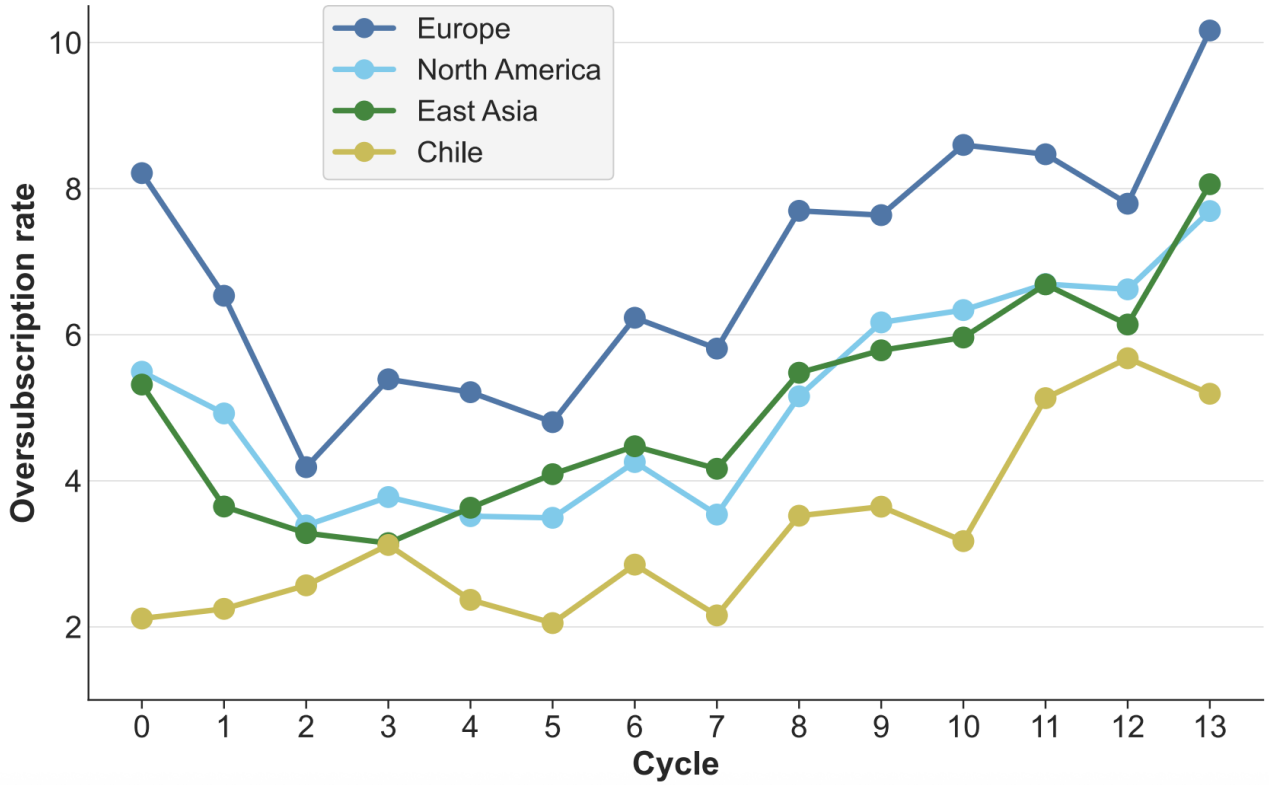
ALMA Imaging workshop, September, 2026

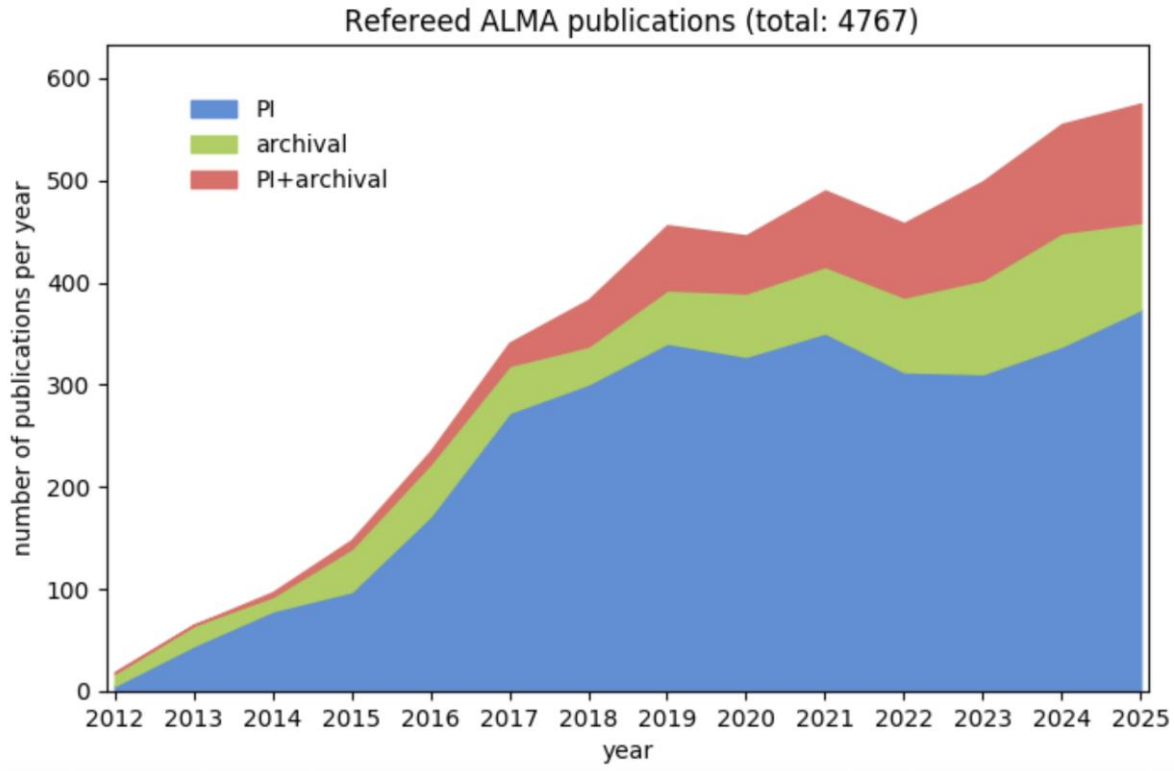
Outline

- Introduction
- Archive webpage (task 1)
- AstroQuery (task 2)
- Similarity (task 3)

Why you need archive?

- Telescope time is very competitive
  - You need to check archive before submitting a proposal
  - Science using ALMA Archive data is increasing





Information from ESO

What you can giving a try today:

- Chose a source and line

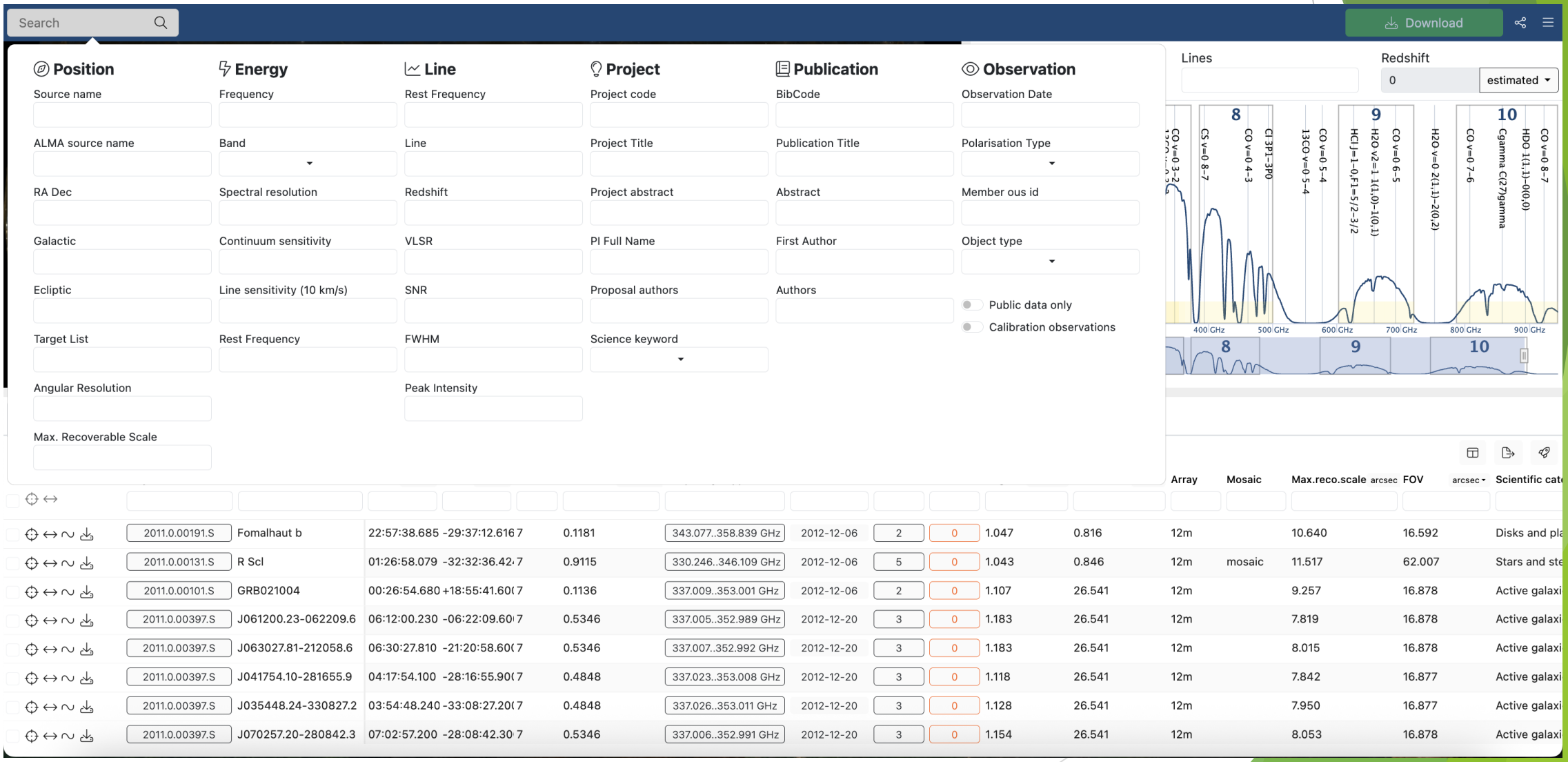
Active galaxies	Cosmology	Disks and planet formation	Galaxy evolution	ISM and star formation	Local Universe	Solar system	Stars and stellar evolution	Sun
NGC 1068	SDP 0.81	HL Tau	Antennae (NGC 4038/39)	Orion KL	LMC (30 Doradus)	Titan	IRC+10216 (CW Leonis)	Quiet Sun region
Centaurus A	HFLS3	TW Hya	Arp 220	IRAS 16293-2422	SMC	Venus	Betelgeuse	Active region / sunspot
Circinus Galaxy	SMM J2135 (Cosmic Eyelash)	PDS 70	M51	Sgr B2(N)	M33	Ceres	VY Canis Majoris	
NGC 5728	SPT0311-58	HD 163296	NGC 253	NGC 6334I	M31	Comet 46P/Wirtanen	Mira	

What you can giving a try today:

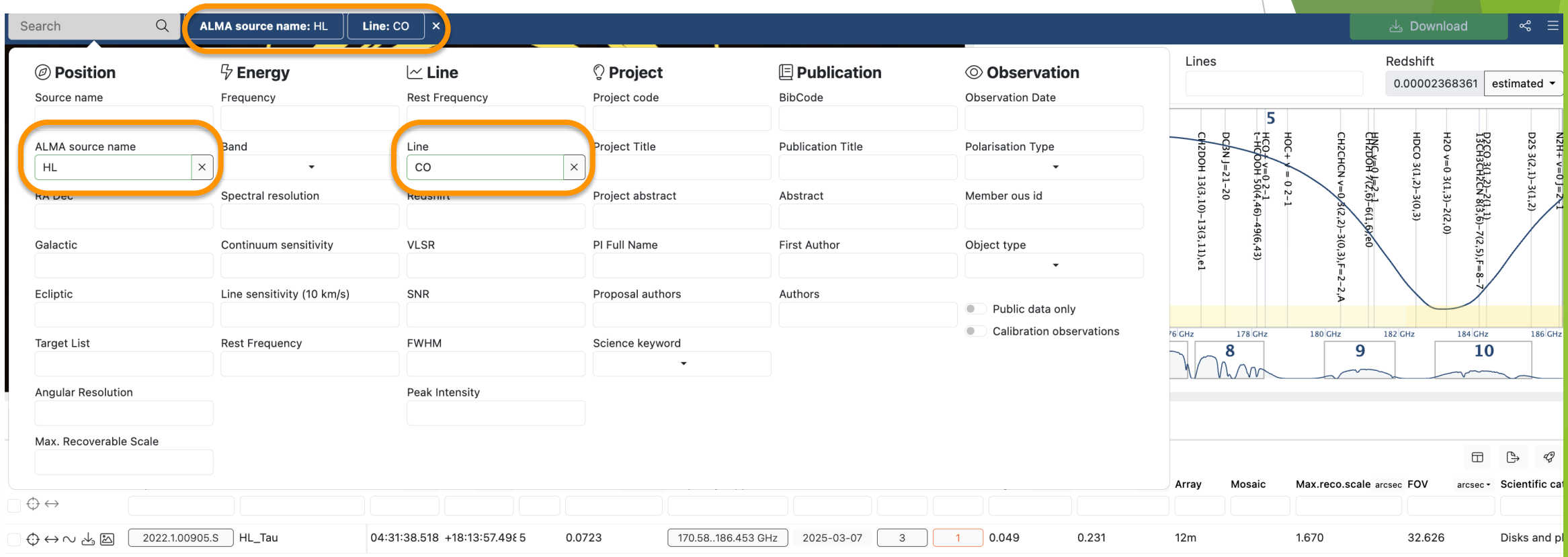
- Chose a source and line

Purpose	Molecule / Line	Typical Band	Notes
General gas tracer	12CO (J=2-1, 3-2)	Band 6, 7	Detected in almost every target -- safe default
Optically thin gas	13CO, C18O	Band 6	Isotopologues; teaches optical-depth effects
Dense gas / star formation	HCN, HCO+	Band 3, 6	Classic dense-gas tracers
Shocks / outflows	SiO	Band 6, 7	Good for jet / outflow discussions
Complex organics	CH3OH, CH3CN	Band 3, 6	Pairs well with Orion KL / Sgr B2
Disk chemistry	HCO+, DCO+, C2H	Band 6, 7	Pairs well with TW Hya / HD 163296
Continuum / dust	(no line -- continuum)	any band	No line processing needed -- good first exercise

Webpage searching



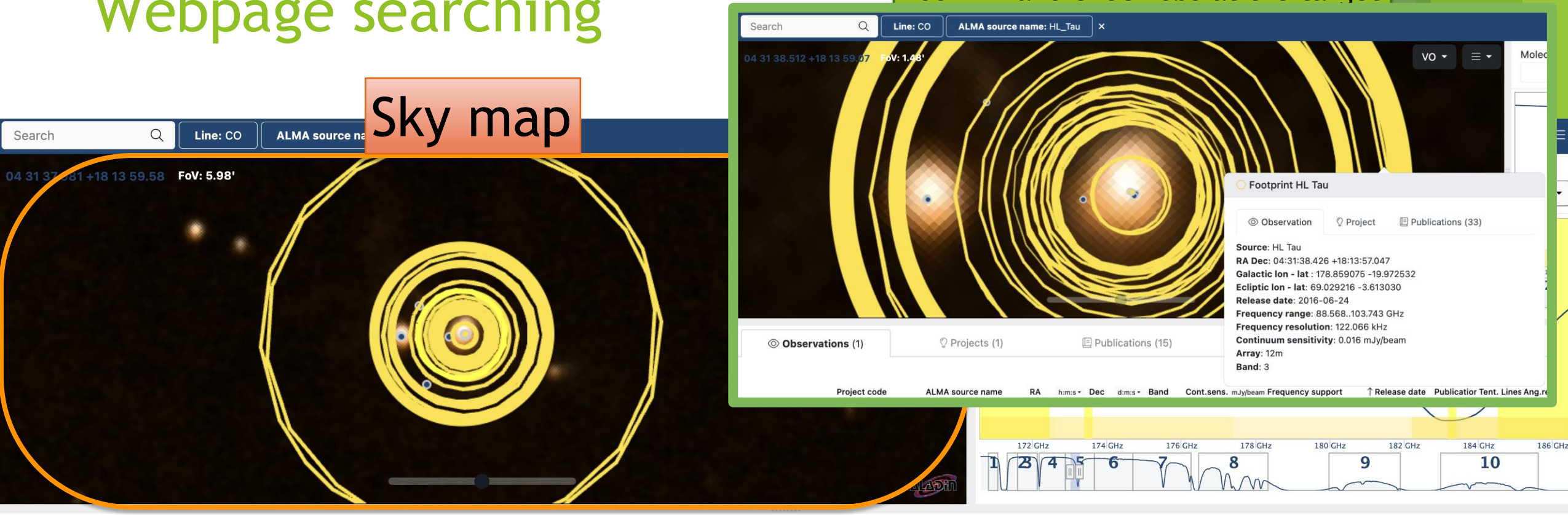
Webpage searching



Webpage searching

Zoom in and check obs at the target

Sky map



Observations (1) Projects (1) Publications (15) Lines (1)

Project code	ALMA source name	RA h:m:s	Dec d:m:s	Band	Cont.sens. mJy/beam	Frequency support	↑ Release date	Publicatior	Tent. Lines	Ang.res. arcsec	Min.vel.res. km/s	Array	Mosaic	Max.reco.scale arcsec	FOV arcsec	Scientific cat
2022.1.00905.S	HL_Tau	04:31:38.518	+18:13:57.498	5	0.0723	170.58..186.453 GHz	2025-03-07	3	1	0.049	0.231	12m		1.670	32.626	Disks and pla

Webpage searching

Have a look the PI's proposal abstract

Search | Line: CO | ALMA source name: HL_Tau | Download

Project 2022.1.00905.S

Project title: The first characterization of the water snowline in a ringed protoplanetary disk

PI name: Facchini, Stefano

Proposal abstract: The water molecule plays a crucial role in the physics and chemistry of planet formation. In particular, the water snowline defines a specific region where dust grains drastically change their properties, promoting the formation of planets. The position of the snowline also defines the chemistry of the available planet building blocks. No direct imaging of the water snowline has been reported yet. With a resolution of 0.1, we will spatially resolve the water snowline in the HL Tau disk, where archival ALMA data show a robust detection of the Band 5 water line at 183.3 GHz. Motivated by this ground-breaking discovery, we will be able to directly connect the radial location of the snowline to the well-characterized grain distribution of this archetypal disk, a long-awaited constraint in any planet formation model. Additional data in Band 7 will further confirm the detection of the warmer water line at 325.1 GHz from the same archival data, opening a new window into the characterization of spatially resolved excitation studies of water vapour in disks. With this exciting discovery in hand, the time is ripe to fully exploit the ALMA potential on this new frontier in planet formation.

Acknowledgement: This paper makes use of the following ALMA data: ADS/JAO.ALMA#2022.1.00905.S ALMA is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada), NSTC and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ.\nIn addition, publications from NA authors must include the standard NRAO acknowledgement: The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.

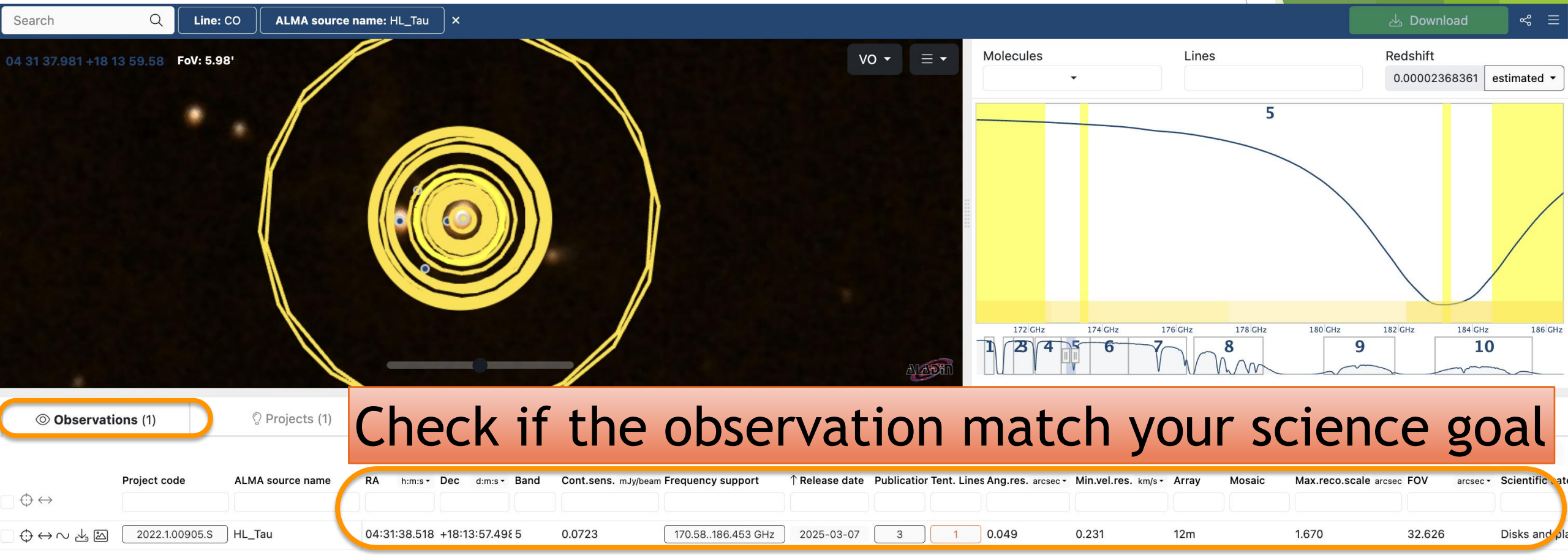
Molecules | Lines | Redshift 0.00002368361 estimated

172 GHz 174 GHz 176 GHz 178 GHz 180 GHz 182 GHz 184 GHz 186 GHz

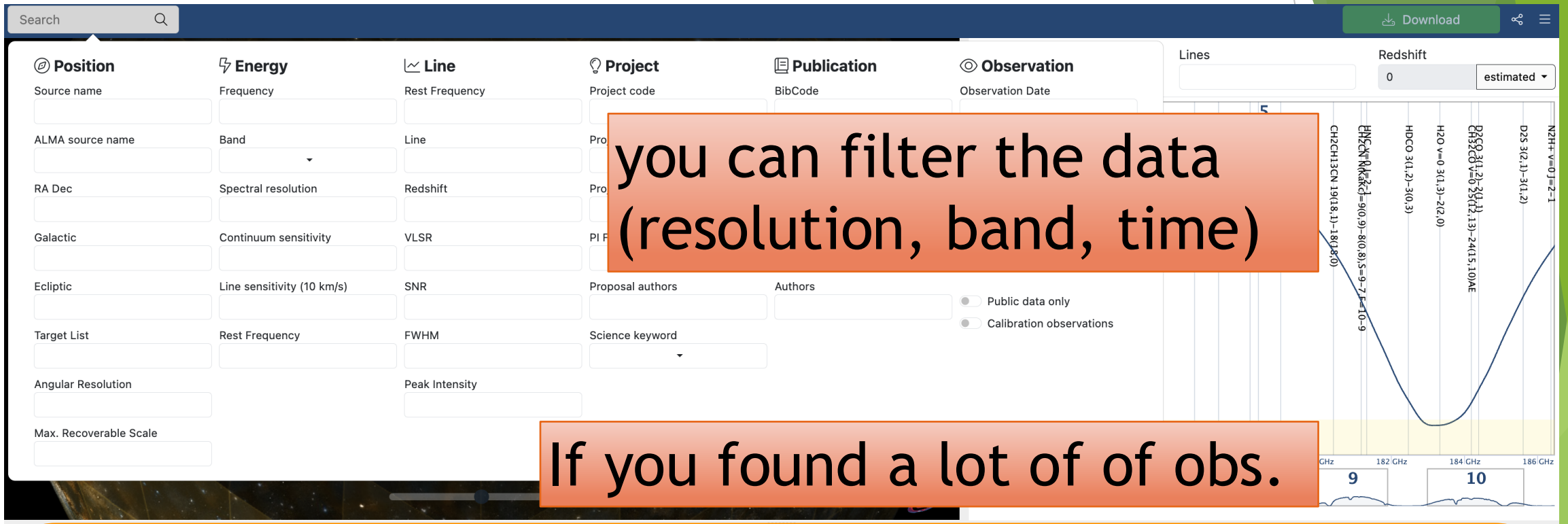
Lines (1)

				Frequency support	Release date	Publicatior	Tent. Lines	Ang.res. arcsec	Min.vel.res. km/s	Array	Mosaic	Max.reco.scale arcsec	FOV arcsec	Scientific cat
2022.1.00905.S	HL_Tau	04:31:38.518 +18:13:57.498 5	0.0723	170.58..186.453 GHz	2025-03-07	3	1	0.049	0.231	12m		1.670	32.626	Disks and pla

Webpage searching



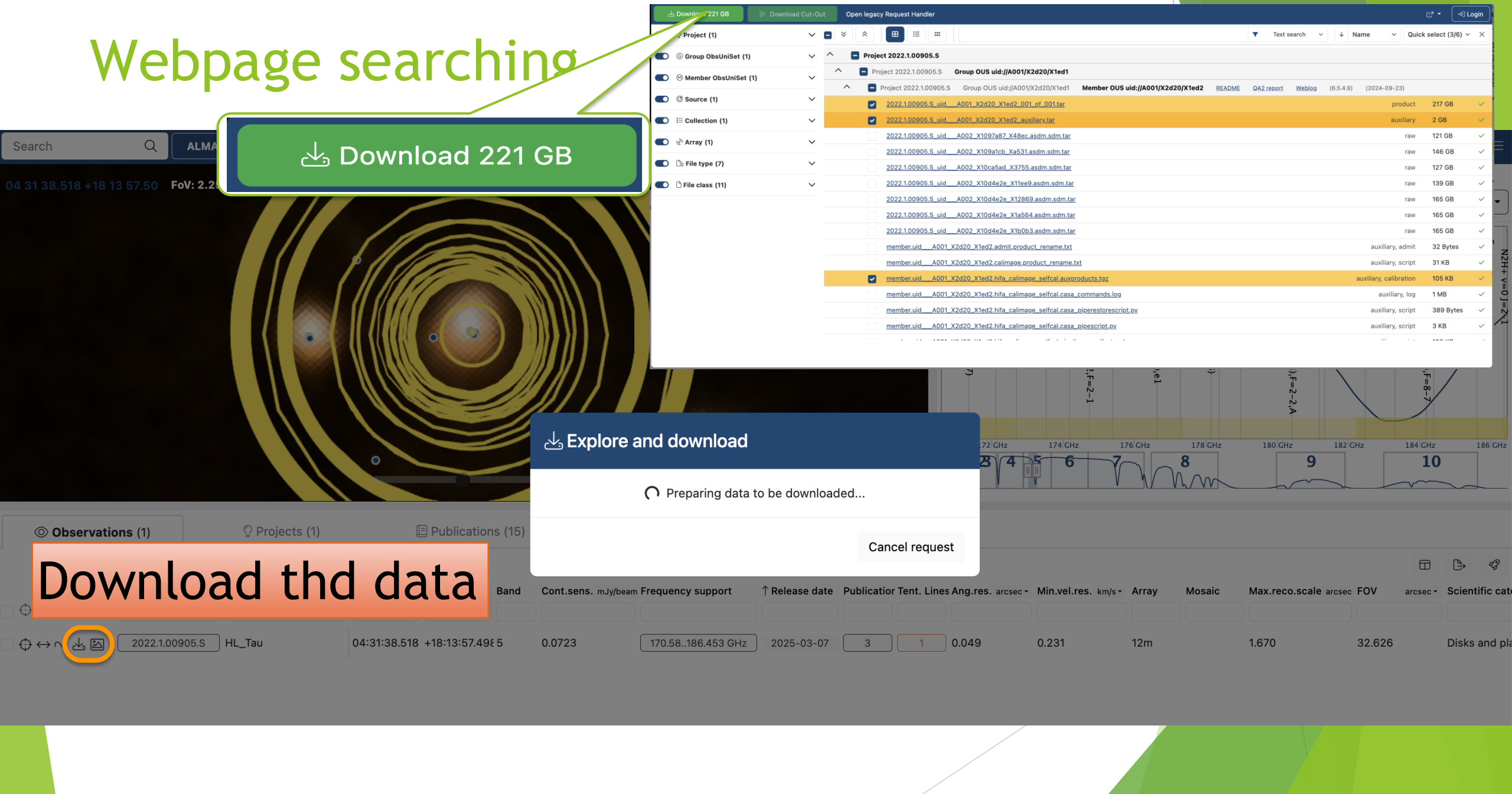
Webpage searching



Observations (97135) | Projects (5611) | Publications (5039) | Lines (161195)

Project code	ALMA source name	RA h:m:s	Dec d:m:s	Band	Cont.sens. mJy/beam	Frequency support	↑ Release date	Publicatior	Tent. Lines	Ang.res. arcsec	Min.vel.res. km/s	Array	Mosaic	Max.reco.scale arcsec	FOV arcsec	Scientific cat
2011.0.00191.S	Fomalhaut b	22:57:38.685	-29:37:12.616	7	0.1181	343.077..358.839 GHz	2012-12-06	2	0	1.047	0.816	12m		10.640	16.592	Disks and pl
2011.0.00131.S	R Scl	01:26:58.079	-32:32:36.42	7	0.9115	330.246..346.109 GHz	2012-12-06	5	0	1.043	0.846	12m	mosaic	11.517	62.007	Stars and st
2011.0.00101.S	GRB021004	00:26:54.680	+18:55:41.60	7	0.1136	337.009..353.001 GHz	2012-12-06	2	0	1.107	26.541	12m		9.257	16.878	Active galax
2011.0.00397.S	J061200.23-062209.6	06:12:00.230	-06:22:09.60	7	0.5346	337.005..352.989 GHz	2012-12-20	3	0	1.183	26.541	12m		7.819	16.878	Active galax
2011.0.00397.S	J063027.81-212058.6	06:30:27.810	-21:20:58.60	7	0.5346	337.007..352.992 GHz	2012-12-20	3	0	1.183	26.541	12m		8.015	16.878	Active galax
2011.0.00397.S	J041754.10-281655.9	04:17:54.100	-28:16:55.90	7	0.4848	337.023..353.008 GHz	2012-12-20	3	0	1.118	26.541	12m		7.842	16.877	Active gal

Webpage searching



Download thd data

Once you get something to download

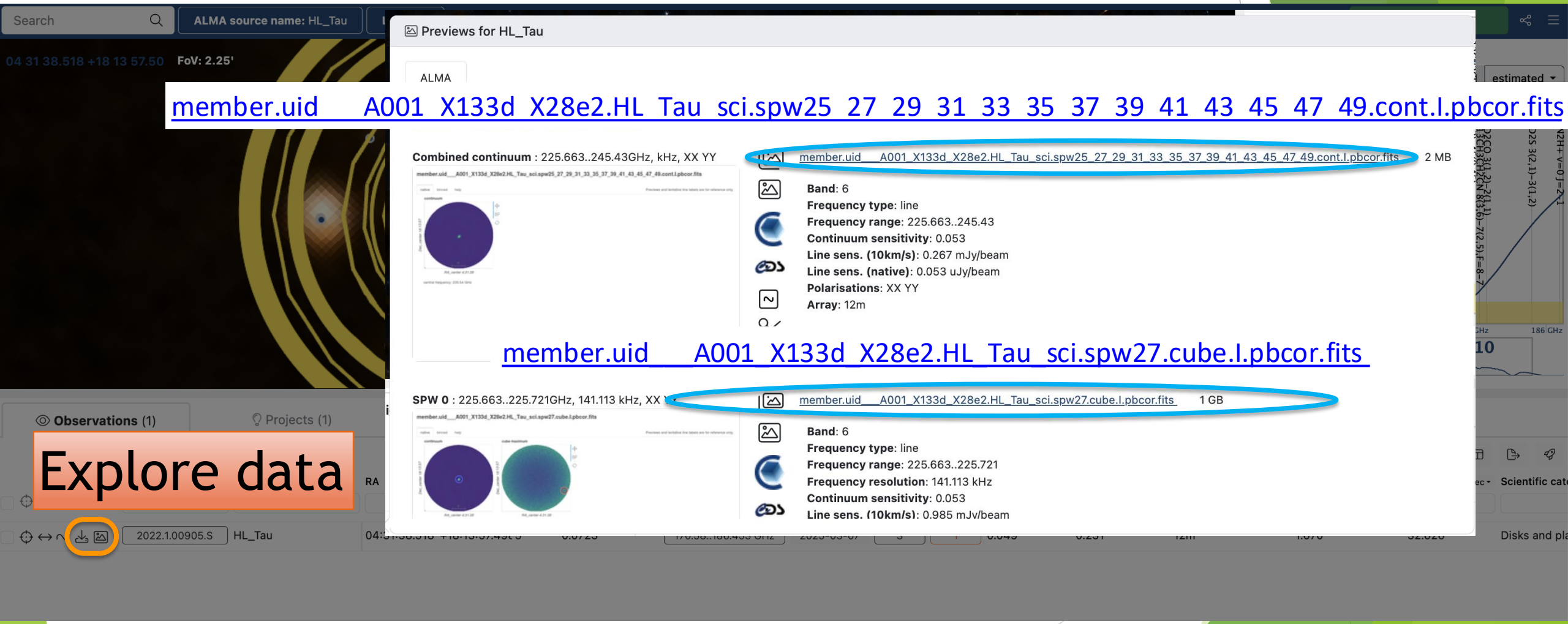
```
2015.1.00041.S
└── science_goal.uid___A001_X340_X1f7
    └── group.uid___A001_X340_X1f8
        └── member.uid___A001_X340_X1f9
            ├── calibration
            ├── log
            ├── product
            ├── qa
            └── script
```

---Project ID
---Science Goal
---Group OUS
---MOUS

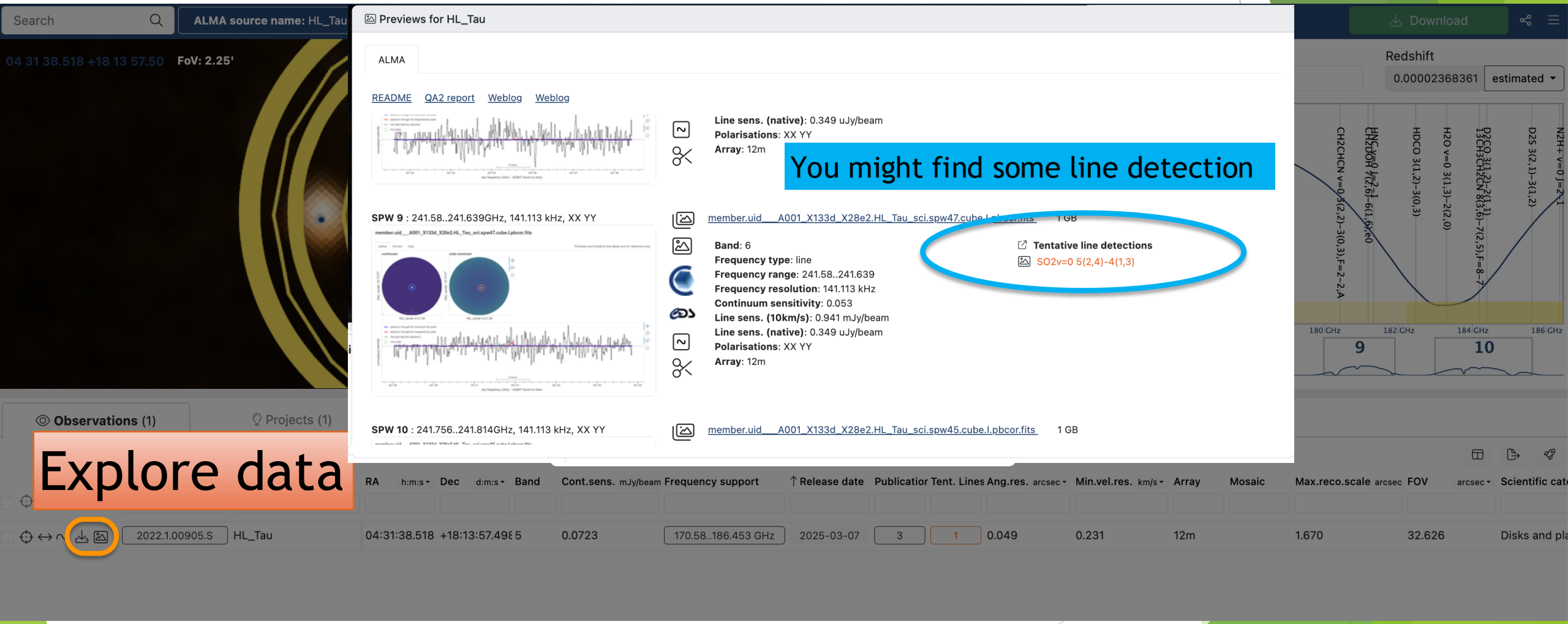
raw_data --------- If you click at the download page (for scriptForPI.py)

```
└── script
    ├── casa_piperestorescript.py
    ├── casa_pipescript.py
    ├── PPR_uid___A001_X340_X1fa.xml
    ├── scriptForImaging.py
    └── scriptForPI.py
```

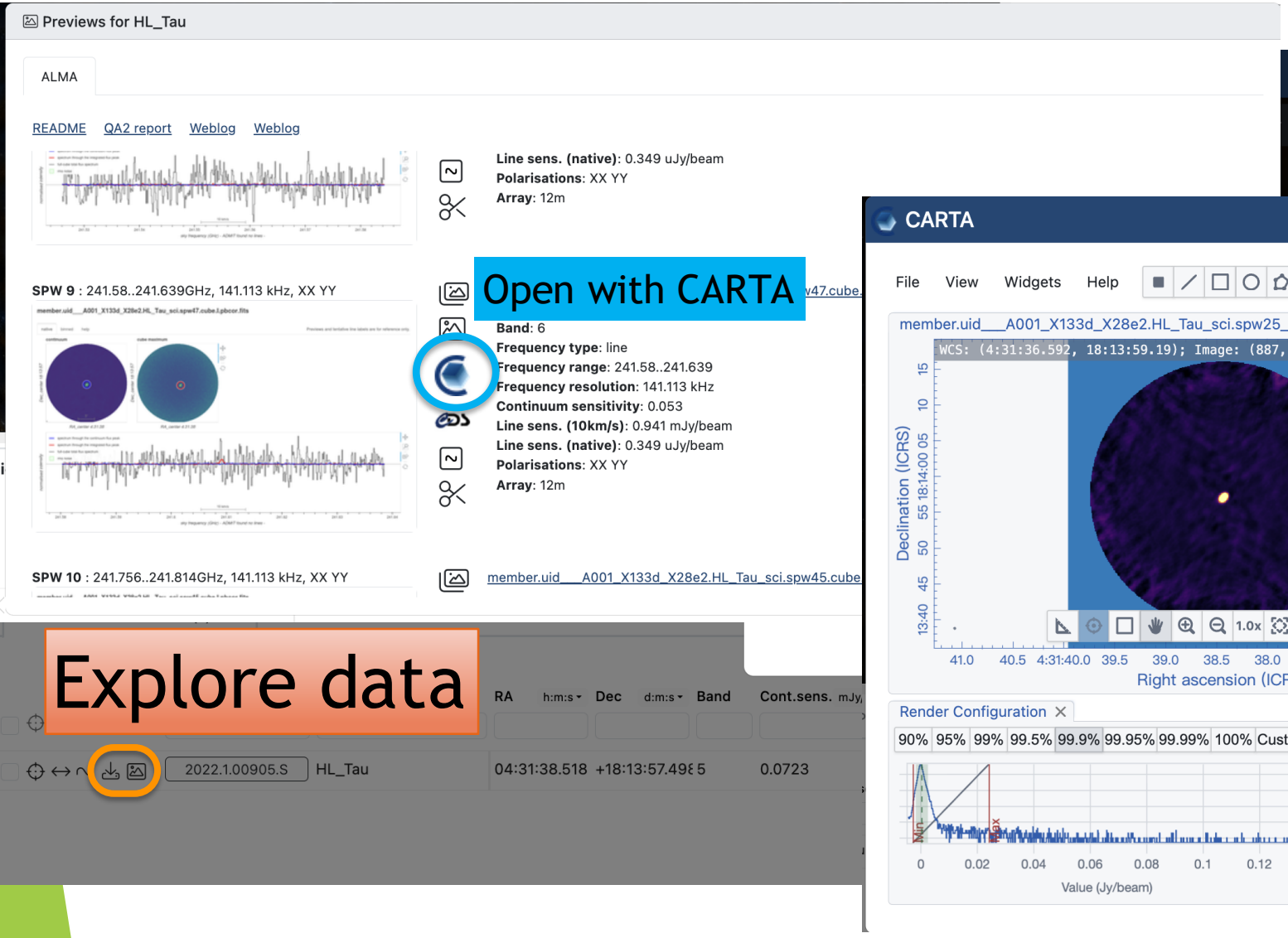
Webpage searching

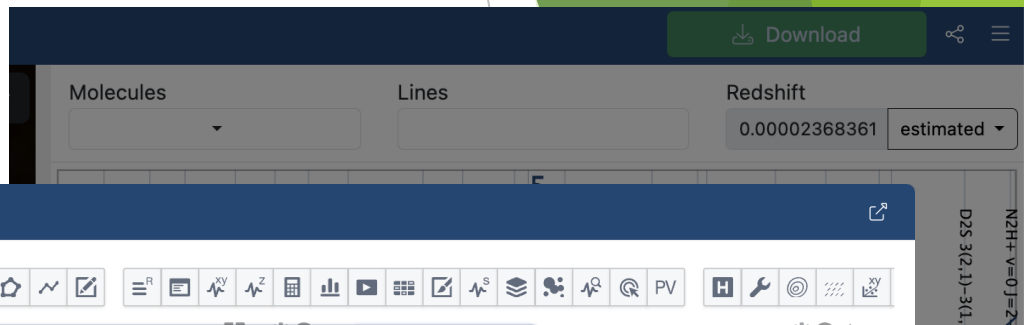


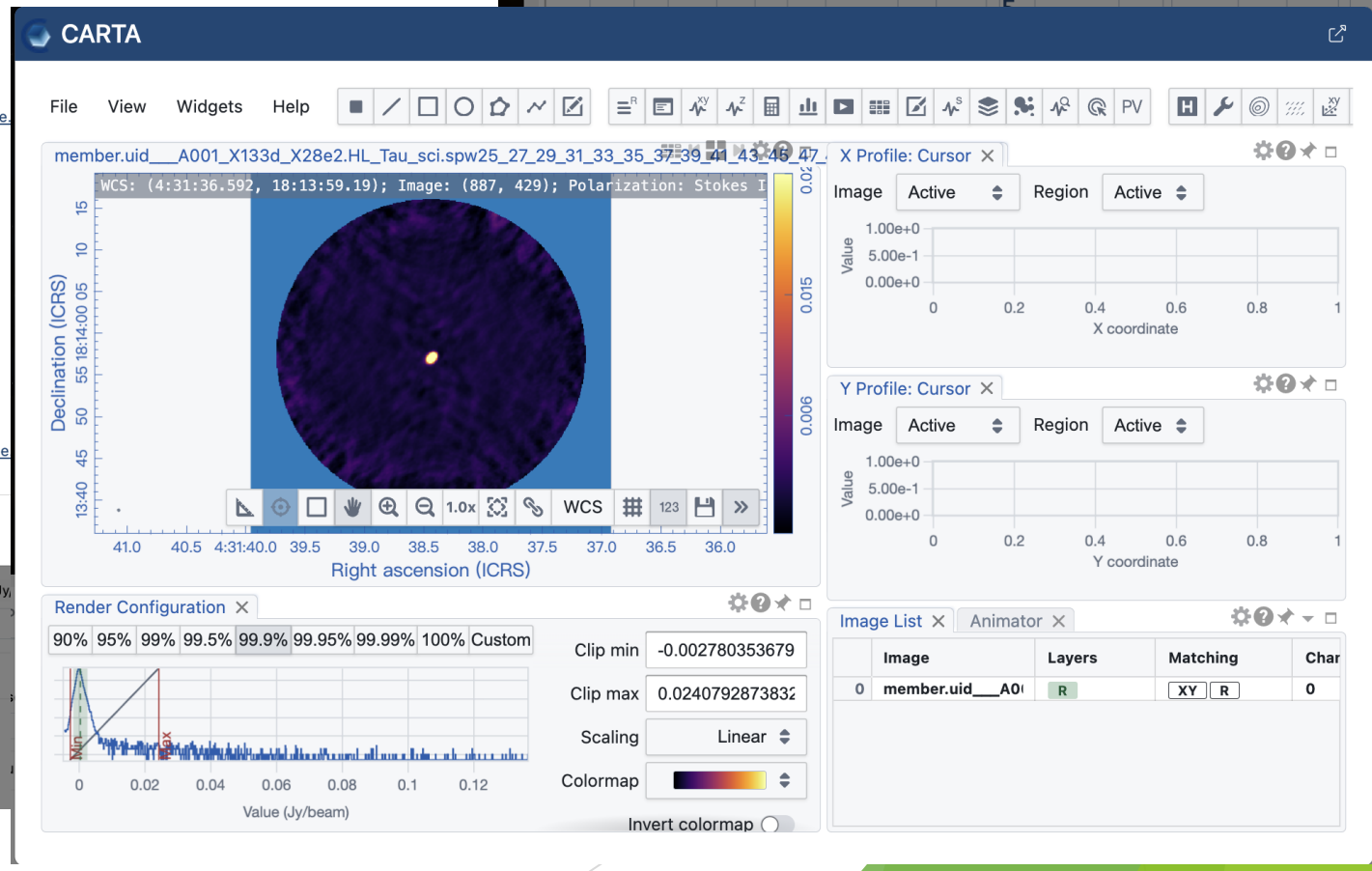
Webpage searching



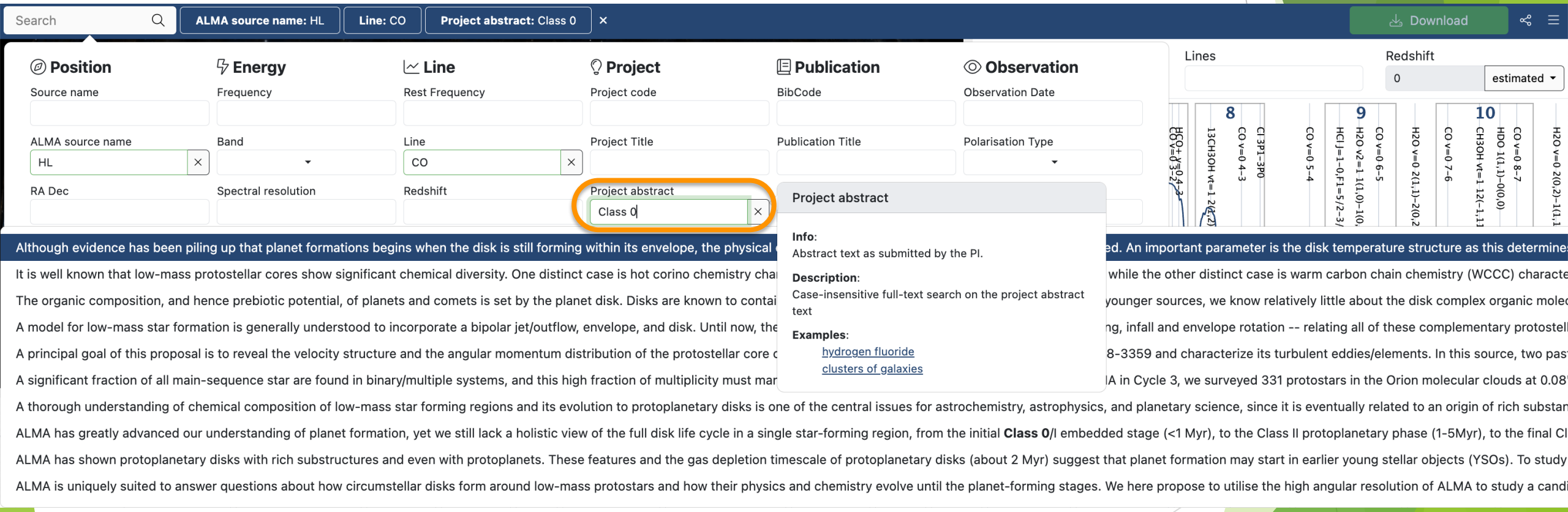
Webpage searching







Webpage searching



Task: combine filters (~10-15 min)

- Go back to your source from the last task (or pick a new one from Slide 4)
- Try the Line filter: search by molecule name (e.g. CO, HCN), or browse the Lines panel on the right
  - If your source is high redshift (e.g. SPT0311-58, HFLS3, SDP0.81, Cosmic Eyelash), set the Redshift field so the line list shows the correct observed frequency
- Combine at least 2 filter categories at once (e.g. Position + Line, or Position + Project abstract)
- Try a Project abstract keyword search related to your science goal (e.g. "outflow", "disk", "AGN") -- how many projects match?
- Check: does the observation's band actually cover the frequency of your line? (rest frequency x (1+z) should fall inside the observed frequency range)
- Open the image in CARTA (quick-look) and take a look -- does what you see actually match what you were hoping to find?
- Bonus: find a project whose abstract really matches your goal, then check its delivered resolution/sensitivity

Astroquery -- script it!

- Same searches as the archive webpage -- reproducible & automatable

Functions we'll use:

- query_object
- query_region
- get_data_info
- download_files

Four scripts today:

- 01 by name -> 02 by region/ADQL -> 03 download -> 04 visualize

Alma.query_object() -- search by name

- Resolves "HL Tau" to coordinates, then runs a cone search

```
(py313) thhsieh@almat2:/almabeegfs/scratch/thhsieh/ImagingWorkshop2026$ python 01_query_by_name.py
Querying ALMA archive for object name 'HL Tau' ...

Total rows returned: 771
Total columns: 73

Distinct target_name values found near 'HL Tau':
  - 04287+1801
  - 04288+1802
  - BHS98 MHO 5
```

```
result = Alma.query_object(
    "HL Tau",
    public=True,
    science=True,
    payload=None,
    enhanced_results=False,
)
```

All 4 parameters (every call sets all of them, even at default):

- public=True -- True/False/None: public only / proprietary only / both
- science=True -- True/False/None: science obs only / calib only / both
- payload=None -- dict: extra ObsCore filters, e.g. {'band_list': ['7']}
- enhanced_results=False -- True adds Quantity columns + a sky-footprint column

The result is an astropy Table

- query_object() returns an astropy Table -- browse it like a dataframe

```
>>> result = Alma.query_object(
...     "HL Tau",
...     public=True,
...     science=True,
...     payload=None,
...     enhanced_results=False,
... )
>>> result.columns
<TableColumns names=('obs_publisher_did','obs_collection','facility_name','instrument_name','obs_id','dataproduct_type','calib_level','collections','target_name','s_ra','s_dec','s_fov'
,'s_region','s_xel1','s_xel2','em_xel','t_xel','pol_xel','s_resolution','t_min','t_max','t_exptime','t_resolution','em_min','em_max','em_res_power','pol_states','o_ucd','access_url','a
ccess_format','access_estsize','proposal_id','data_rights','gal_longitude','gal_latitude','band_list','em_resolution','bandwidth','antenna_arrays','is_mosaic','obs_release_date','spati
al_resolution','frequency_support','frequency','velocity_resolution','obs_creator_name','pub_title','first_author','authors','pub_abstract','publication_year','proposal_abstract','sche
dblock_name','proposal_authors','sensitivity_10kms','cont_sensitivity_bandwidth','pwv','group_ous_uid','member_ous_uid','asdm_uid','obs_title','type','scan_intent','science_observation
','spatial_scale_max','qa2_passed','bib_reference','science_keyword','scientific_category','pi_userid','pi_name','spectral_resolution','lastModified')>
>>> result['obs_publisher_did','obs_id','target_name','s_ra','s_dec','proposal_id','spatial_resolution','pi_name']
<Table length=775>
     obs_publisher_did                      obs_id                  target_name       s_ra            s_dec        proposal_id    spatial_resolution       pi_name
                                                                                       deg             deg                              arcsec
          str33                             str64                     str256        float64         float64          str64           float64              str256
------------------------- ------------------------------------------ ---------- ---------------- ---------------- ------------- ------------------ ----------------
ADS/JAO.ALMA#2011.0.00619.S    uid://A001/Xca/X5.source.L1551 NE.spw.17    L1551 NE 67.93540416666667 18.142131111111112 2011.0.00619.S  0.5717667379425295 Takakuwa, Shigehisa
ADS/JAO.ALMA#2011.0.00619.S    uid://A001/Xca/X5.source.L1551 NE.spw.19    L1551 NE 67.93540416666667 18.142131111111112 2011.0.00619.S  0.5717667379425295 Takakuwa, Shigehisa
ADS/JAO.ALMA#2011.0.00619.S    uid://A001/Xca/X5.source.L1551 NE.spw.23    L1551 NE 67.93540416666667 18.142131111111112 2011.0.00619.S  0.5717667379425295 Takakuwa, Shigehisa
ADS/JAO.ALMA#2011.0.00619.S    uid://A001/Xca/X5.source.L1551 NE.spw.21    L1551 NE 67.93540416666667 18.142131111111112 2011.0.00619.S  0.5717667379425295 Takakuwa, Shigehisa
ADS/JAO.ALMA#2019.1.00393.S uid://A001/X1465/X3167.source.HL_Tau.spw.25      HL_Tau 67.91020070802584  18.23256011073085 2019.1.00393.S  0.9202653524457668           Zhang, Ke
ADS/JAO.ALMA#2019.1.00393.S uid://A001/X1465/X3167.source.HL_Tau.spw.29      HL_Tau 67.91020070802584  18.23256011073085 2019.1.00393.S  0.9202653524457668           Zhang, Ke
ADS/JAO.ALMA#2019.1.00393.S uid://A001/X1465/X3167.source.HL_Tau.spw.31      HL_Tau 67.91020070802584  18.23256011073085 2019.1.00393.S  0.9202653524457668           Zhang, Ke
ADS/JAO.ALMA#2019.1.00393.S uid://A001/X1465/X3167.source.HL_Tau.spw.27      HL_Tau 67.91020070802584  18.23256011073085 2019.1.00393.S  0.9202653524457668           Zhang, Ke
ADS/JAO.ALMA#2019.1.00393.S uid://A001/X1465/X3167.source.HL_Tau.spw.35      HL_Tau 67.91020070802584  18.23256011073085 2019.1.00393.S  0.9202653524457668           Zhang, Ke
ADS/JAO.ALMA#2019.1.00393.S uid://A001/X1465/X3167.source.HL_Tau.spw.33      HL_Tau 67.91020070802584  18.23256011073085 2019.1.00393.S  0.9202653524457668           Zhang, Ke
```

The result is an astropy Table

- query_object() returns an astropy Table -- browse it like a dataframe
  Filter with your parameter
  result[result[‘spatial_resolution]<0.05][…]

```
>>> result[result['spatial_resolution']<0.05]['obs_publisher_did','obs_id','target_name','s_ra','s_dec','proposal_id','spatial_resolution','pi_name']
<Table length=64>
     obs_publisher_did                       obs_id                    target_name       s_ra            s_dec         proposal_id    spatial_resolution       pi_name
                                                                                          deg             deg                              arcsec
           str33                             str64                       str256        float64         float64          str64          float64              str256
--------------------------- ------------------------------------------- ---------- ---------------- ---------------- ------------ ------------------- ------------------
 ADS/JAO.ALMA#2017.1.00388.S uid://A001/X1288/Xb6c.source.L1551_IRS_5.spw.25 L1551_IRS_5 67.89198750003972 18.134694444449106 2017.1.00388.S 0.04457437409379539 Liu, Hauyu Baobab
 ADS/JAO.ALMA#2017.1.00388.S uid://A001/X1288/Xb6c.source.L1551_IRS_5.spw.27 L1551_IRS_5 67.89198750003972 18.134694444449106 2017.1.00388.S 0.04457437409379539 Liu, Hauyu Baobab
 ADS/JAO.ALMA#2017.1.00388.S uid://A001/X1288/Xb6c.source.L1551_IRS_5.spw.29 L1551_IRS_5 67.89198750003972 18.134694444449106 2017.1.00388.S 0.04457437409379539 Liu, Hauyu Baobab
```

- Or Query_object with pyload={‘spatial_resolution’: ‘<0.05’}

```
>>> result = Alma.query_object(
...     "HL Tau",
...     public=True,
...     science=True,
...     payload={'spatial_resolution': '<0.05'},
...     enhanced_results=False,
... )

>>>
>>> result['obs_publisher_did','obs_id','target_name','s_ra','s_dec','proposal_id','spatial_resolution','pi_name']
<Table length=64>
     obs_publisher_did                       obs_id                    target_name       s_ra            s_dec         proposal_id    spatial_resolution       pi_name
                                                                                          deg             deg                              arcsec
           str33                             str64                       str256        float64         float64          str64          float64              str256
--------------------------- ------------------------------------------- ---------- ---------------- ---------------- ------------ ------------------- ------------------
 ADS/JAO.ALMA#2017.1.00388.S uid://A001/X1288/Xb6c.source.L1551_IRS_5.spw.25 L1551_IRS_5 67.89198750003972 18.134694444449106 2017.1.00388.S 0.04457437409379539 Liu, Hauyu Baobab
 ADS/JAO.ALMA#2017.1.00388.S uid://A001/X1288/Xb6c.source.L1551_IRS_5.spw.27 L1551_IRS_5 67.89198750003972 18.134694444449106 2017.1.00388.S 0.04457437409379539 Liu, Hauyu Baobab
 ADS/JAO.ALMA#2017.1.00388.S uid://A001/X1288/Xb6c.source.L1551_IRS_5.spw.29 L1551_IRS_5 67.89198750003972 18.134694444449106 2017.1.00388.S 0.04457437409379539 Liu, Hauyu Baobab
```

Alma.query_region() -- search by region

- Cone search around explicit coordinates -- same idea as query_object

```
(py313) thhsieh@almat2:/almabeegfs/scratch/thhsieh/ImagingWorkshop2026$ python 02_query_by_region.py
Resolving 'HL Tau' to coordinates via astropy's name resolver ...
  RA  = 67.910461 deg
  Dec = 18.232739 deg

Running query_region() with radius = 30.0 arcsec ...

Total rows returned: 337

Distinct target_name values within the search radius:
  - HL Tau
  - HLTau
```

```
result = Alma.query_region(
    coord,
    search_radius,
    public=True,
    science=True,
    payload=None,
    enhanced_results=False,
)
```

All 6 parameters:

- coordinate=coord -- SkyCoord (or string), the search center
- radius=30*u.arcsec -- Quantity, the search radius
- public=True -- public only / proprietary only / both
- science=True -- science obs only / calib only / both
- payload=None -- dict, extra ObsCore filters
- enhanced_results=False -- adds Quantity columns + sky-footprint

Alma.get_data_info() -- list files

- Lists every file/package attached to one "**member_ous_uid**"
  i.e. result['member_ous_uid']='uid://A002/X91a40d/X4' from query
- **Info = Alma.get_data_info('uid://A002/X91a40d/X4')**

```
(py313) thhsieh@almat2:/almabeegfs/scratch/thhsieh/ImagingWorkshop2026$ python 03_get_data_and_download.py
Requesting file listing for uid://A002/X91a40d/X4 ...
Total files/packages listed: 16

All files, sorted by size:
        0.01 MB  2011.0.00015.SV_2011-08-01_006_of_006.tar
        0.01 MB  2011.0.00015.SV_2011-08-01_003_of_006.tar
       15.61 MB  2011.0.00015.SV_2011-08-01_004_of_006.tar
       16.30 MB  2011.0.00015.SV_2011-08-01_001_of_006.tar
     1863.05 MB  2011.0.00015.SV_2011-08-01_002_of_006.tar
     7584.31 MB  2011.0.00015.SV_uid___A002_X928687_X446.asdm.sdm.tar
```

```
info = Alma.get_data_info(TARGET_UID)
```

All 4 parameters:

- uids='uid://A002/X91a40d/X4' -- member_ous_uid or asdm_uid
- expand_tarfiles=False -- True lists files INSIDE each package
- with_auxiliary=True -- include logs/weblogs/calibration tables
- with_rawdata=True -- include raw ASDM packages (huge!)

Alma.get_data_info() -- list files

- Lists every file/package attached to one "**member_ous_uid**"
  i.e. result['member_ous_uid']='uid://A002/X91a40d/X4' from query
- **Info = Alma.get_data_info('uid://A002/X91a40d/X4')**

The url Link

product

```
>>> info
<Table length=16>
          ID                                                access_url                                                 s
        object                                               object
-------------------- ------------------------------------------------------------------------------------------------ -
uid://A002/X91a40d/X4           https://almascience.nao.ac.jp/dataPortal/2011.0.00015.SV_2011-08-01_001_of_006.tar
uid://A002/X91a40d/X4           https://almascience.nao.ac.jp/dataPortal/2011.0.00015.SV_2011-08-01_002_of_006.tar
uid://A002/X91a40d/X4           https://almascience.nao.ac.jp/dataPortal/2011.0.00015.SV_2011-08-01_003_of_006.tar
uid://A002/X91a40d/X4           https://almascience.nao.ac.jp/dataPortal/2011.0.00015.SV_2011-08-01_004_of_006.tar
uid://A002/X91a40d/X4           https://almascience.nao.ac.jp/dataPortal/2011.0.00015.SV_2011-08-01_005_of_006.tar
                 ...                                                                                                ...
uid://A002/X91a40d/X4 https://almascience.nao.ac.jp/dataPortal/2011.0.00015.SV_uid___A002_X920302_X826.asdm.sdm.tar
uid://A002/X91a40d/X4 https://almascience.nao.ac.jp/dataPortal/2011.0.00015.SV_uid___A002_X920302_Xacd.asdm.sdm.tar
uid://A002/X91a40d/X4 https://almascience.nao.ac.jp/dataPortal/2011.0.00015.SV_uid___A002_X925649_X2e6.asdm.sdm.tar
uid://A002/X91a40d/X4 https://almascience.nao.ac.jp/dataPortal/2011.0.00015.SV_uid___A002_X925649_X4ab.asdm.sdm.tar
```

Raw data (asdm.sdm)

Alma.get_data_info() -- list files

- Lists every file/package attached to one "member_ous_uid"
  i.e. result['member_ous_uid']='uid://A002/X91a40d/X4' from query
- Info = Alma.get_data_info('uid://A002/X91a40d/X4')

```
(py313) thhsieh@almat2:/almabeegfs/scratch/thhsieh/ImagingWorkshop2026$ python 03_get_data_and_download.py
Requesting file listing for uid://A002/X91a40d/X4 ...
Total files/packages listed: 16

All files, sorted by size:
        0.01 MB  2011.0.00015.SV_2011-08-01_006_of_006.tar
        0.01 MB  2011.0.00015.SV_2011-08-01_003_of_006.tar
       15.61 MB  2011.0.00015.SV_2011-08-01_004_of_006.tar
```

```
downloaded = Alma.download_files(
    [chosen_url],
    savedir=savedir,
    cache=True,
    continuation=True,
    skip_unauthorized=True,
    verify_only=False,
)
```

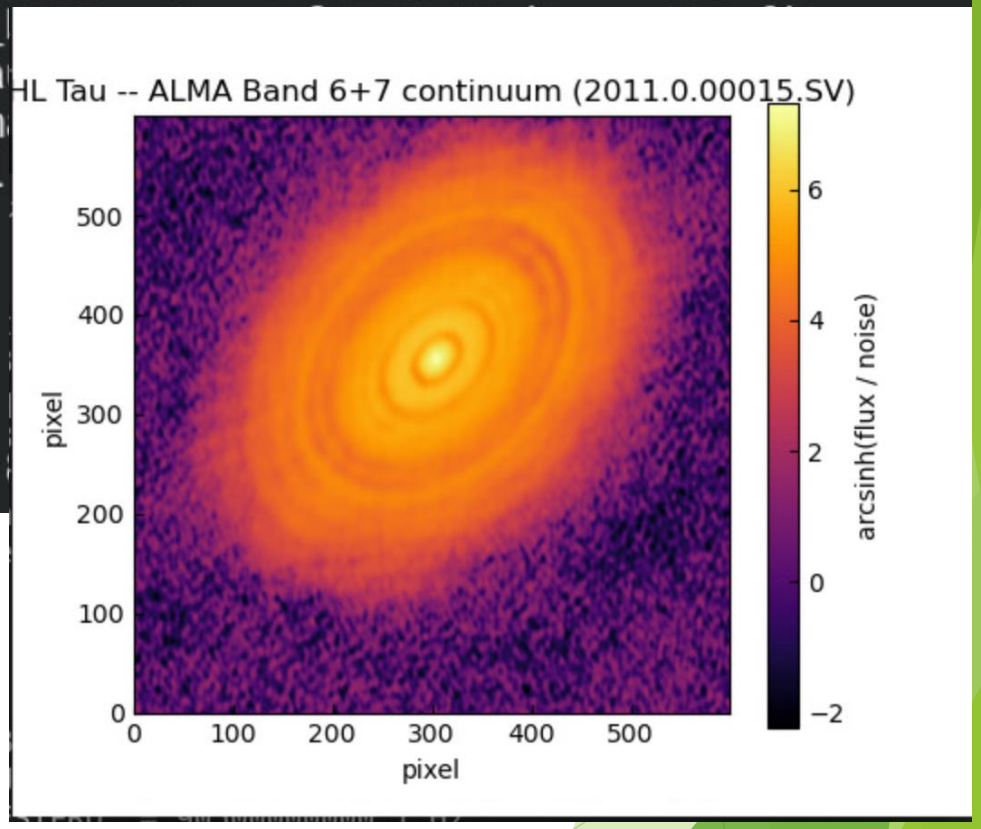
All 5 parameters:

- files=[chosen_url] -- list of access_url strings
- savedir='./alma_downloads' -- where to save (must already exist!)
- cache=True -- skip re-download if already present
- continuation=True -- resume a partial download
- skip_unauthorized=True -- silently skip files you can't access
- verify_only=False -- True = dry run, just check reachability

Open it with CARTA or astropy.io.fits

```
(py313) thhsieh@almat2:/almabeegfs/scratch/thhsieh/ImagingWorkshop2026$ python 04_visualize.py
Extracting alma_downloads/2011.0.00015.SV_2011-08-01_001_of_006.tar -> alma_extracted ...
Opening alma_extracted/HLTau_Band6+7_ReferenceImages/HLTau_
Filename: alma_extracted/HLTau_Band6+7_ReferenceImages/HLTa
No.    Name      Ver    Type      Cards   Dimensions   Form
  0  PRIMARY       1 PrimaryHDU    1701   (2048, 2048, 1, 1

Key header values:
  OBJECT   = HL_Tau
  BUNIT    = Jy/beam
  RESTFRQ  = 90500000000.1 Hz
  BMAJ/BMIN/BPA (synthesized beam) = 9.303485146827e-06, 5.
```



Calls used:

- tf.extractall(EXTRACT_DIR, filter='data') -- filter='data' = safe extraction
- fits.open(fits_path) -- returns header + data
- np.squeeze(data) -- CASA's 4D array -> 2D image

Task: run it yourself (~10-15 min)

```
(py313) thhsieh@almat7:/almabeegfs/scratch/thhsieh/ImagingWorkshop2026$ python
Python 3.13.7 | packaged by Anaconda, Inc. | (main, Sep  9 2025, 19:59:03) [GCC 1
Type "help", "copyright", "credits" or "license" for more information.
Ctrl click to launch VS Code Native REPL
>>> from astroquery.alma import Alma
>>> Alma.help()

Most common ALMA query keywords are listed below. These keywords are part of the A
sentation (3rd column). They were also present in original ALMA Web form and, for
 names (2nd column).
```

```
result = Alma.query_object(
    "HL Tau",
    public=True,
    science=True,
    payload=None,
    enhanced_results=False,
)
```

```
result = Alma.query_region(
    coord,
    search_radius,
    public=True,
    science=True,
    payload=None,
    enhanced_results=False,
)
```

```
result['member_ous_uid']
```

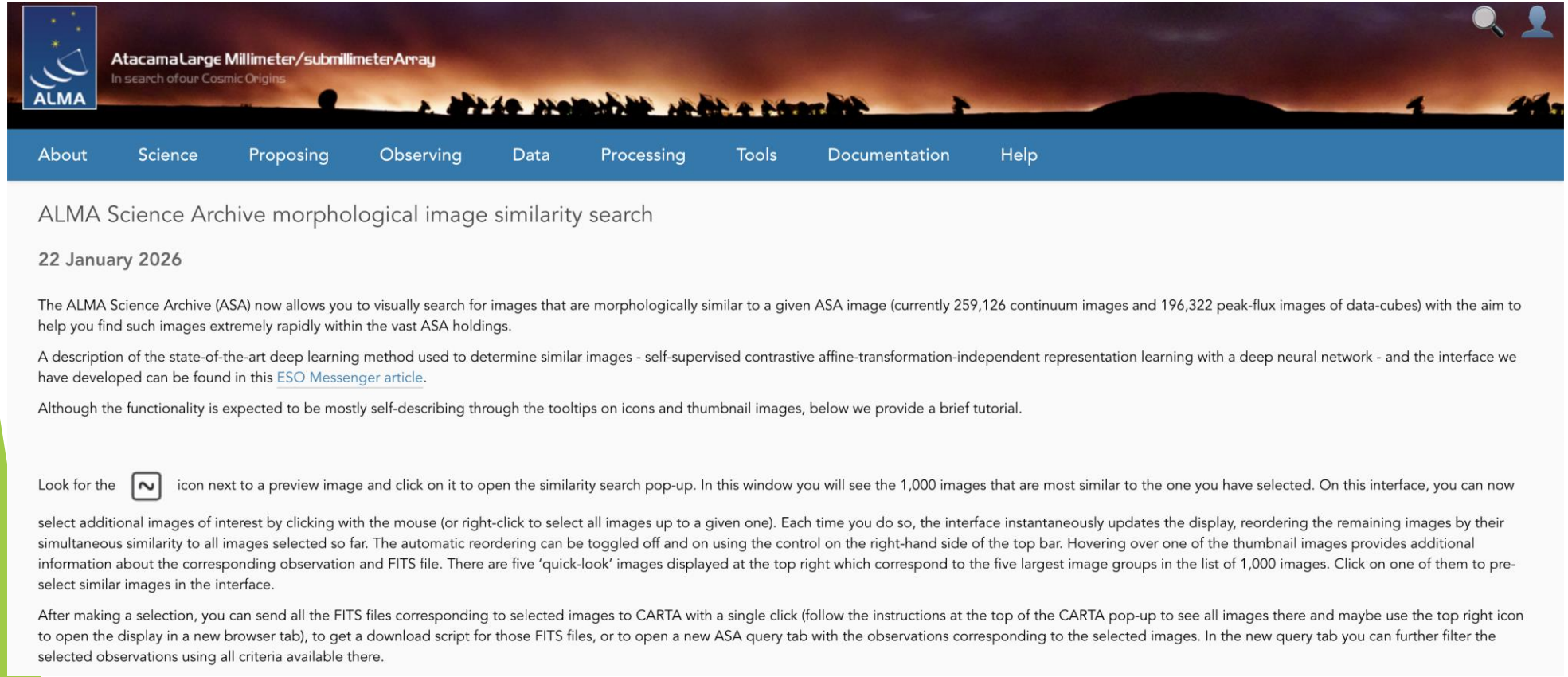
```
info = Alma.get_data_info(TARGET_UID)
```

```
downloaded = Alma.download_files(
    [chosen_url],
    savedir=savedir,
    cache=True,
    continuation=True,
    skip_unauthorized=True,
    verify_only=False,
)
```

- Open 01_query_by_name.py, change "HL Tau" to your own source (Slide 4)
- Re-run 01 -> 02 -> 03 -> 04 in order
  - Trying to filter the results after query
  - Trying to filter the results before query
  - update the target UID by hand between steps
  - Download the product: Is this what you want?
  - Open the file with CARTA or Plot the data
- Try Alma.help() to find a filter keyword we didn't cover in the demo
- Compare your final plot to what you saw in CARTA earlier (Slide 17) -- does it match?

Introduction

- ALMA Science Archive morphological image similarity search



Stoehr et al.

https://almascience.eso.org/news/alma-science-archive-morphological-image-similarity-search

Introduction

- ALMA Science Archive morphological image similarity search

Astronomical News

DOI: 10.18727/0722-6691/5396

Morphological Image Similarity Search on the ALMA Science Archive Query Interface Using Deep Unsupervised Contrastive Representation Learning

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Andrea Farago[1]
Stefan Curiban[1]
Alisdair Manning[1]
Jorge Garcia[2]
Pei-Ying Hsieh[3]
Andrew Lipnicky[4]
Adele Plunkett[4]

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[2] Joint ALMA Observatory, Santiago, Chile
[3] National Astronomical Observatory of Japan, Mitaka, Japan

image similarity search has been offered in an astronomical science archive.

Introduction

The amount of astronomical data is growing exponentially (for example, Stoehr, 2019) resulting in an exponential increase of data available per astronomer. No longer data but now astronomers are becoming — or have already become — the rare resource in astronomy (Stoehr et al., 2015). For science archives like the learning without using human classification (labels). Recently, however, a breakthrough has been achieved such that contrastive unsupervised methods perform as well as, or even better than, supervised methods. Such methods have already been applied successfully to astrophysics. For a summary see Huertas-Company et al. (2023).

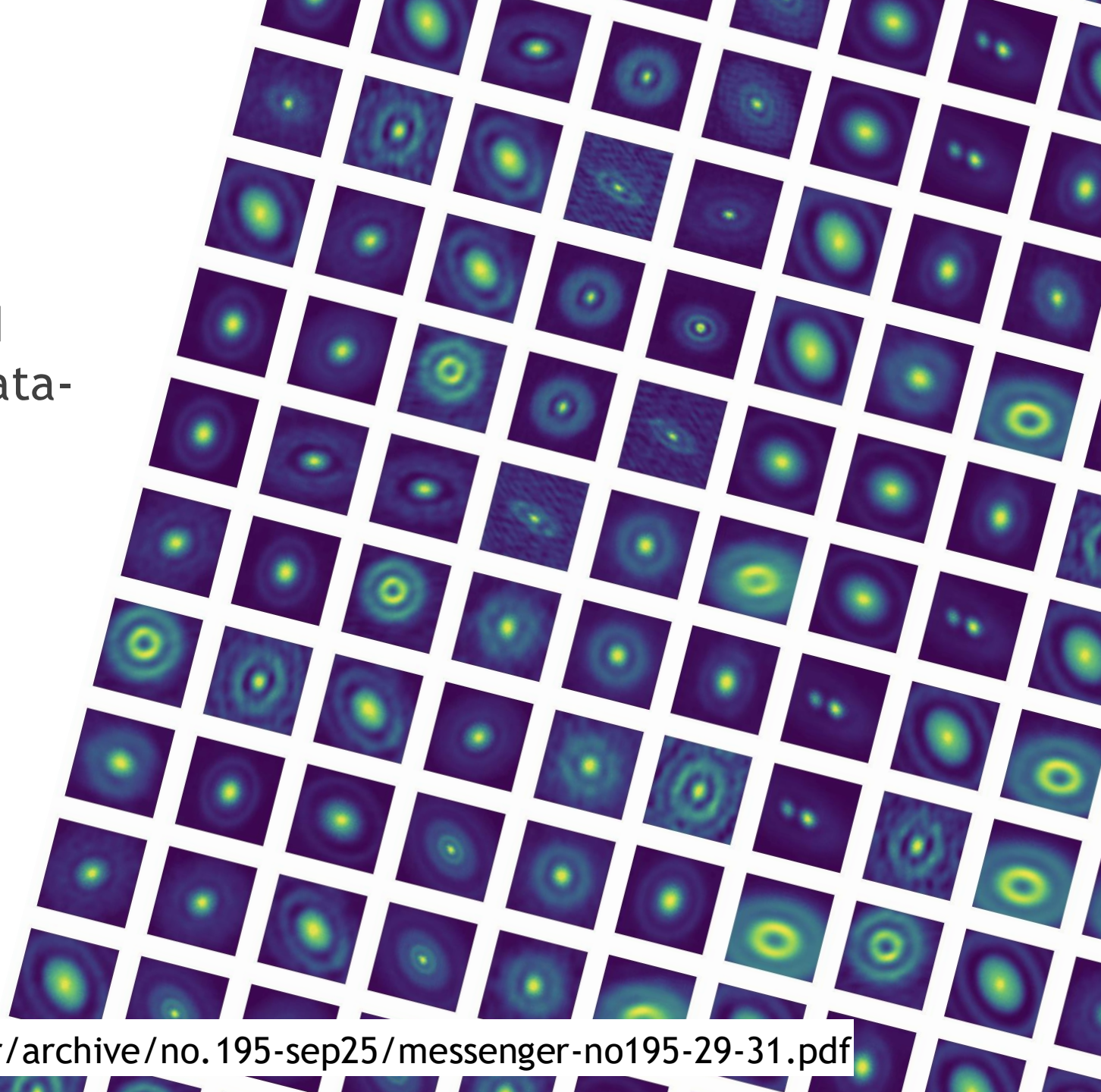
Here, we use the SimCLR algorithm (Chen et al., 2020) in the implementation made by da Costa et al. (2022)[2]. SimCLR uses self-supervised learning by applying

Stoehr et al.

https://almascience.eso.org/news/alma-science-archive-morphological-image-similarity-search

Introduction

- Applied to a vast archive of 259,126 continuum images and 196,322 peak-flux images of data-cubes
- Model: A deep neural network utilizing self-supervised contrastive representation learning

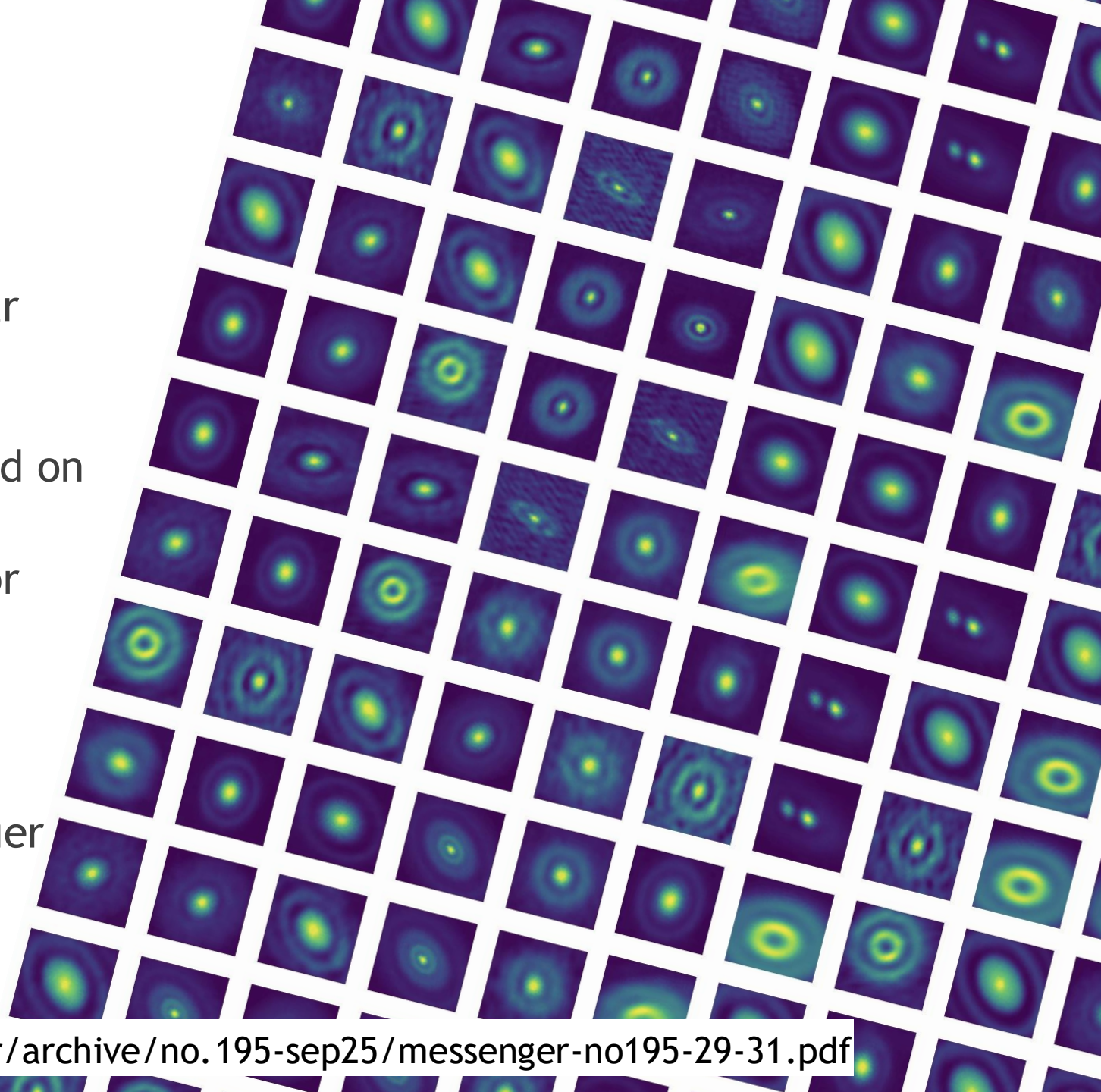


Stoehr et al.

https://www.eso.org/sci/publications/messenger/archive/no.195-sep25/messenger-no195-29-31.pdf

Introduction

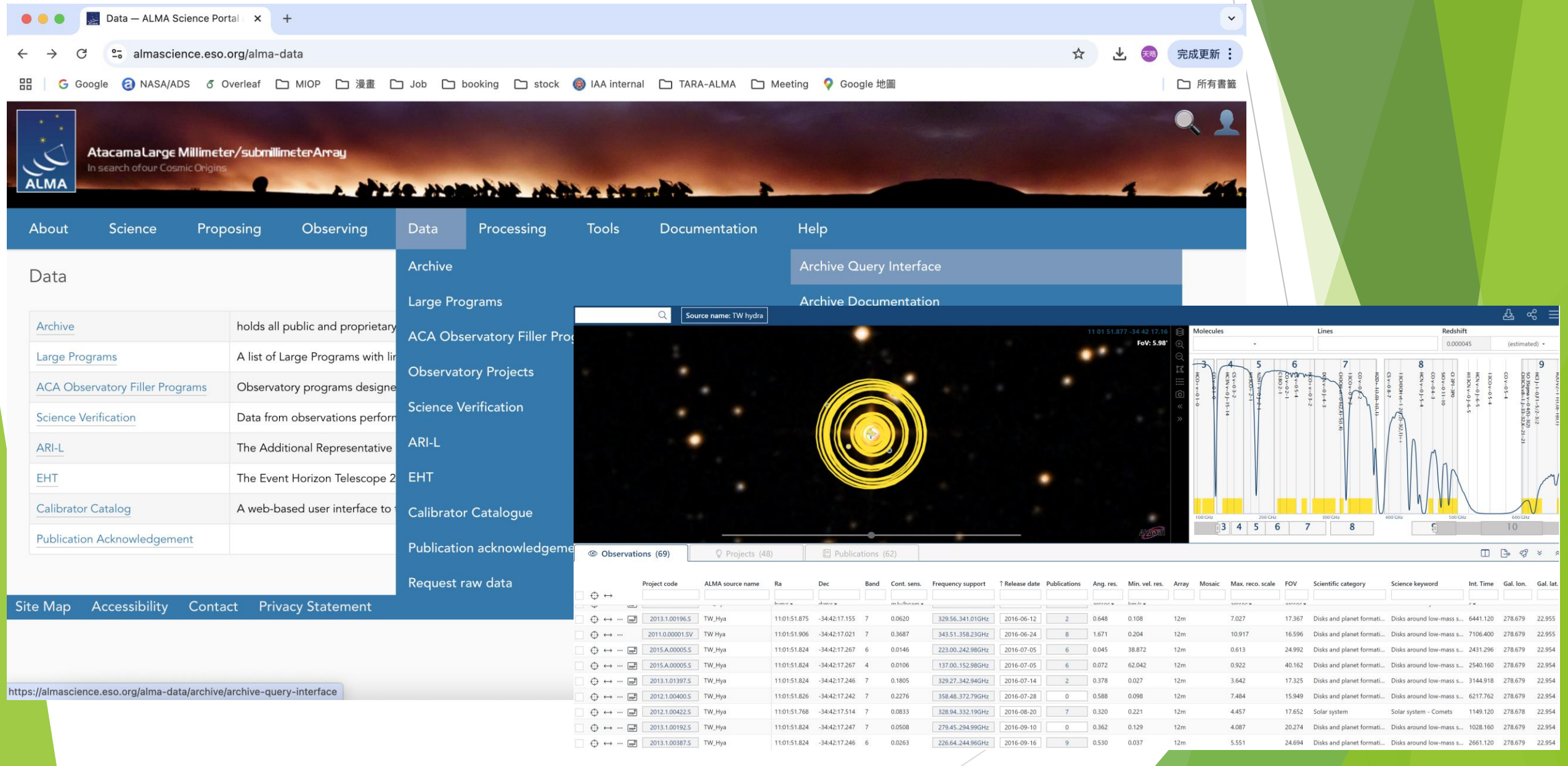
- **Search:** Click the icon next to a preview image to find 1,000 similar images
- **Refine:** Select images to instantly reorder the remaining results based on your combination
- **Explore:** Hover over thumbnails for FITS details, or click the top-right 'quick-look' images to find major groups
- **Export:** Send files to CARTA, get a download script, or open a new quer tab



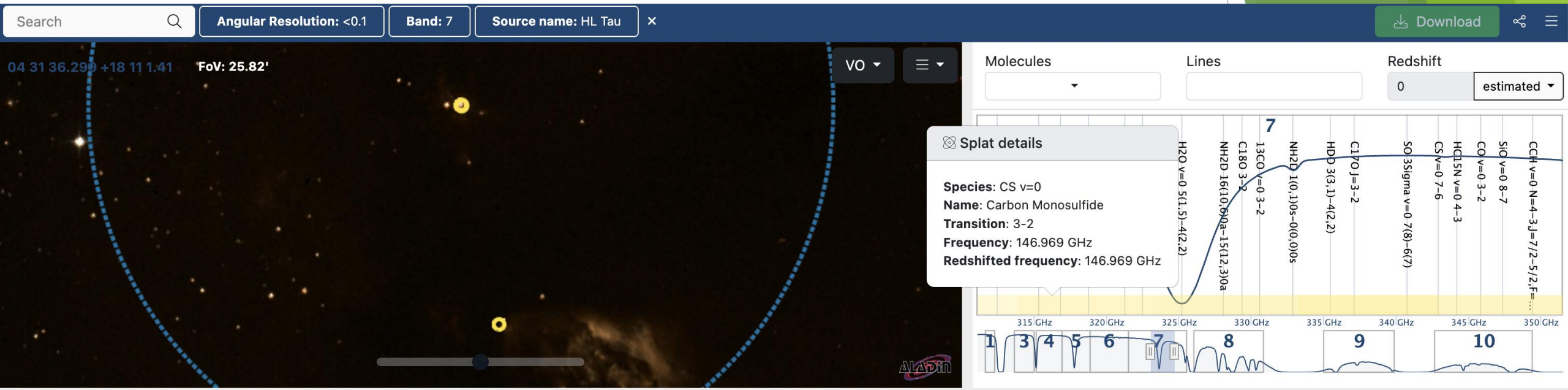
Stoehr et al.

https://www.eso.org/sci/publications/messenger/archive/no.195-sep25/messenger-no195-29-31.pdf

ALMA Archive



ALMA Archive

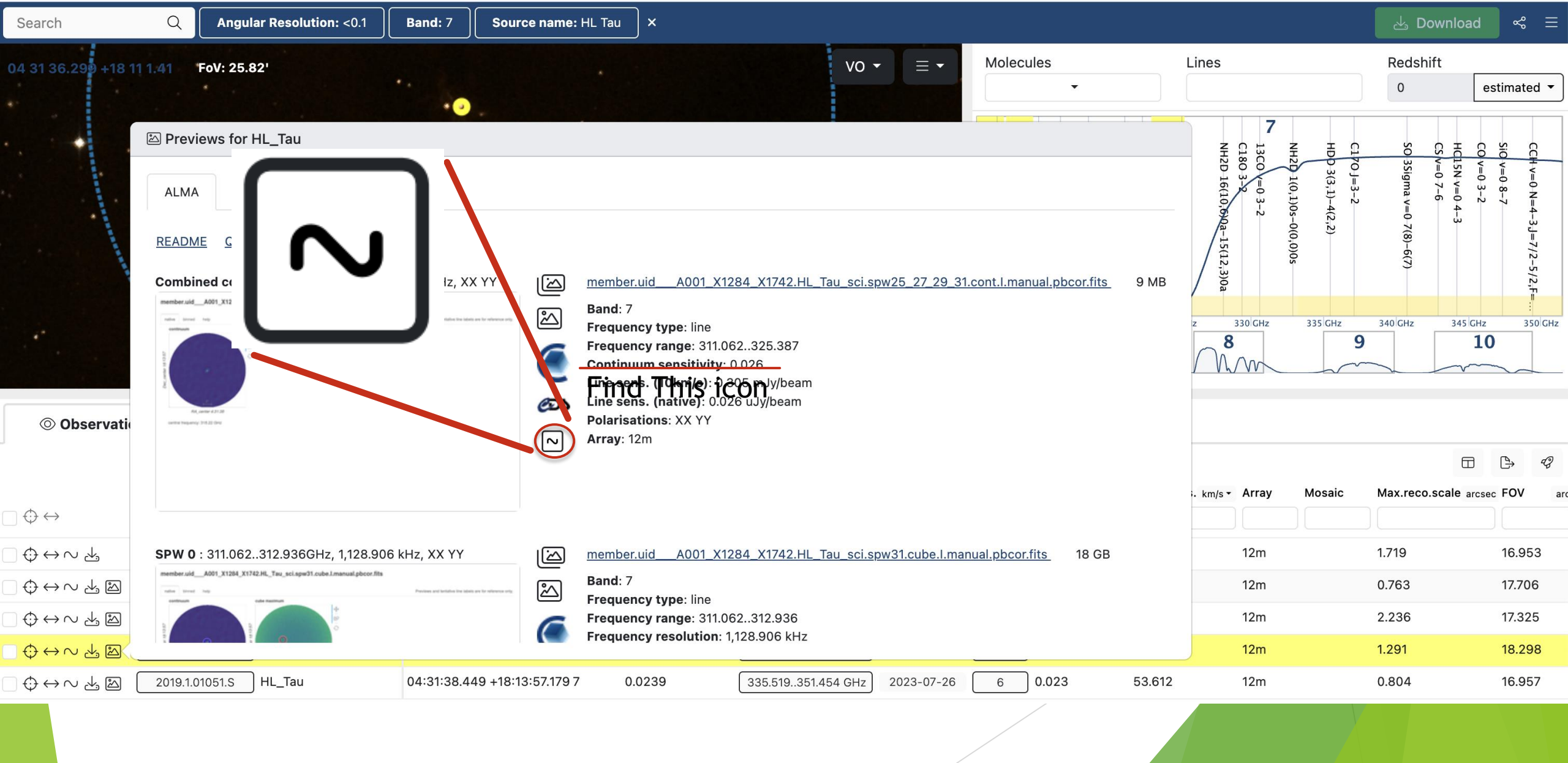


Observations (5) | Projects (4) | Publications (54)

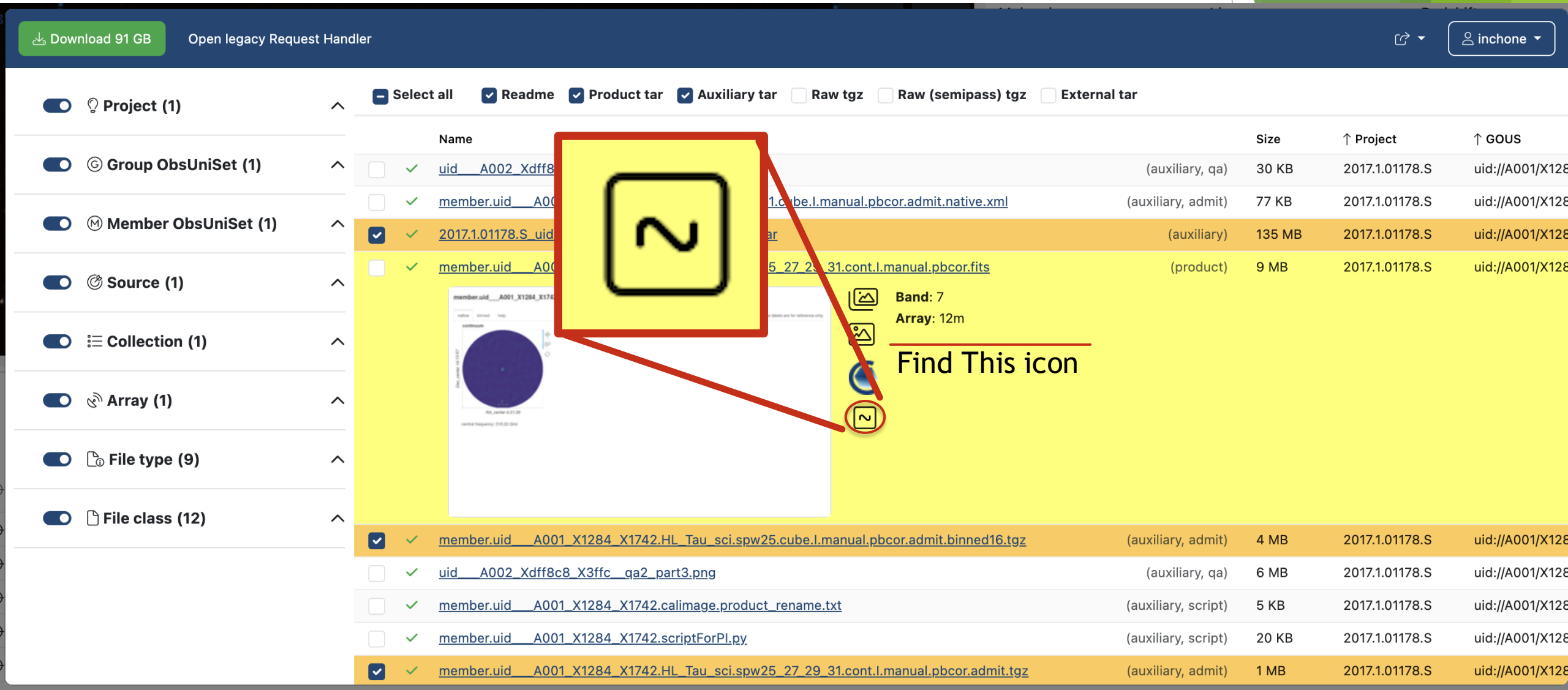
Project code	ALMA source name	RA h:m:s	Dec d:m:s	Band	Cont.sens. mJy/beam	Frequency support	Release date	Publicatior	Ang.res. arcsec	Min.vel.res. km/s	Array	Mosaic	Max.reco.scale arcsec	FOV
2011.0.00015.SV	HL_Tau	04:31:38.426	+18:13:57.047	7	0.0357	335.498..351.486 GHz	2016-06-24	33	0.020	26.654	12m		1.719	16.953
2017.1.01178.S	HL_Tau	04:31:38.425	+18:13:57.242	7	0.0310	320.991..336.737 GHz	2019-02-22	5	0.038	0.263	12m		0.763	17.706
2016.1.00138.S	L1551IRS5	04:31:34.140	+18:08:05.100	7	0.0763	329.096..343.117 GHz	2019-05-09	11	0.083	0.214	12m		2.236	17.325
2017.1.01178.S	HL_Tau	04:31:38.425	+18:13:57.242	7	0.0265	311.062..325.387 GHz	2021-02-12	5	0.082	0.260	12m		1.291	18.298
2019.1.01051.S	HL_Tau	04:31:38.449	+18:13:57.179	7	0.0239	335.519..351.454 GHz	2023-07-26	6	0.023	53.612	12m		0.804	16.957

Download/view the data

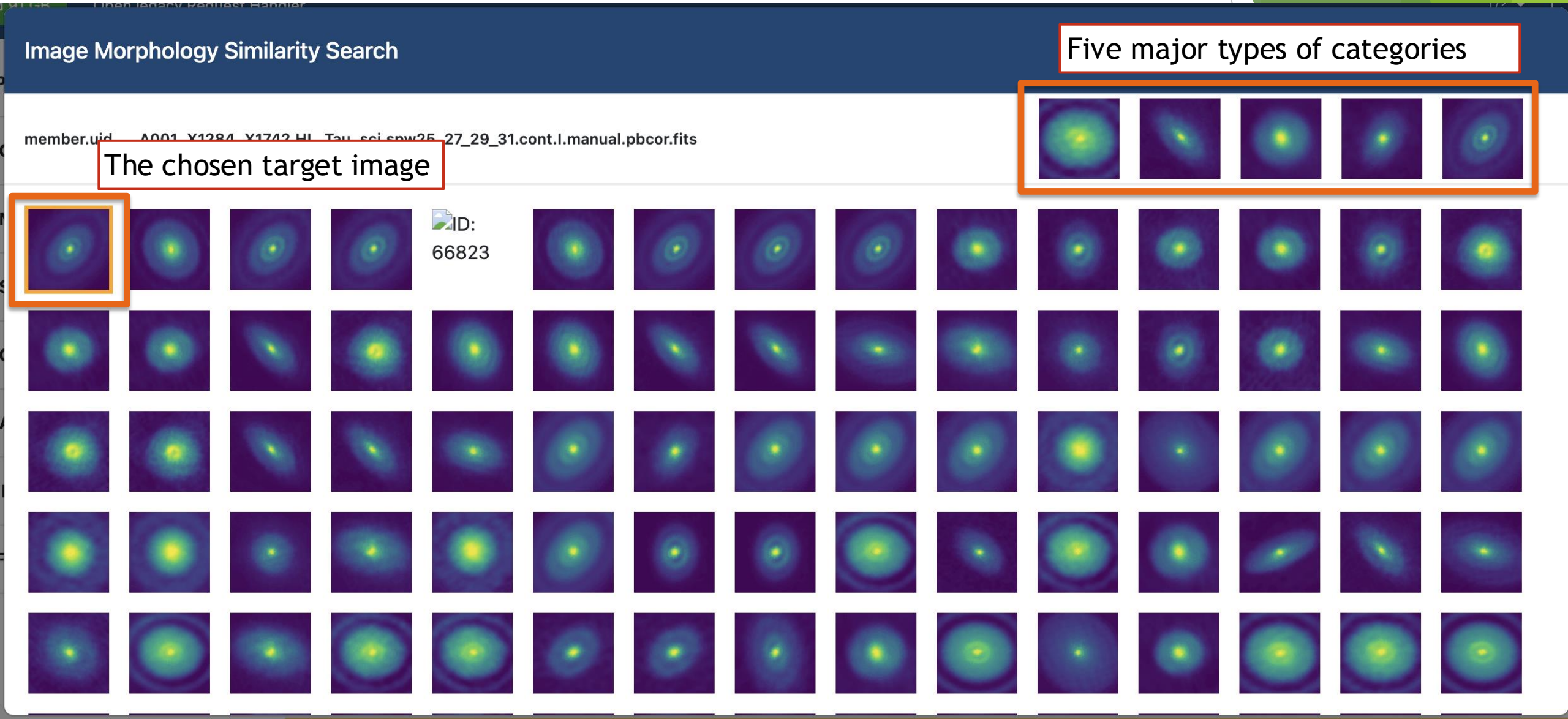
ALMA Archive



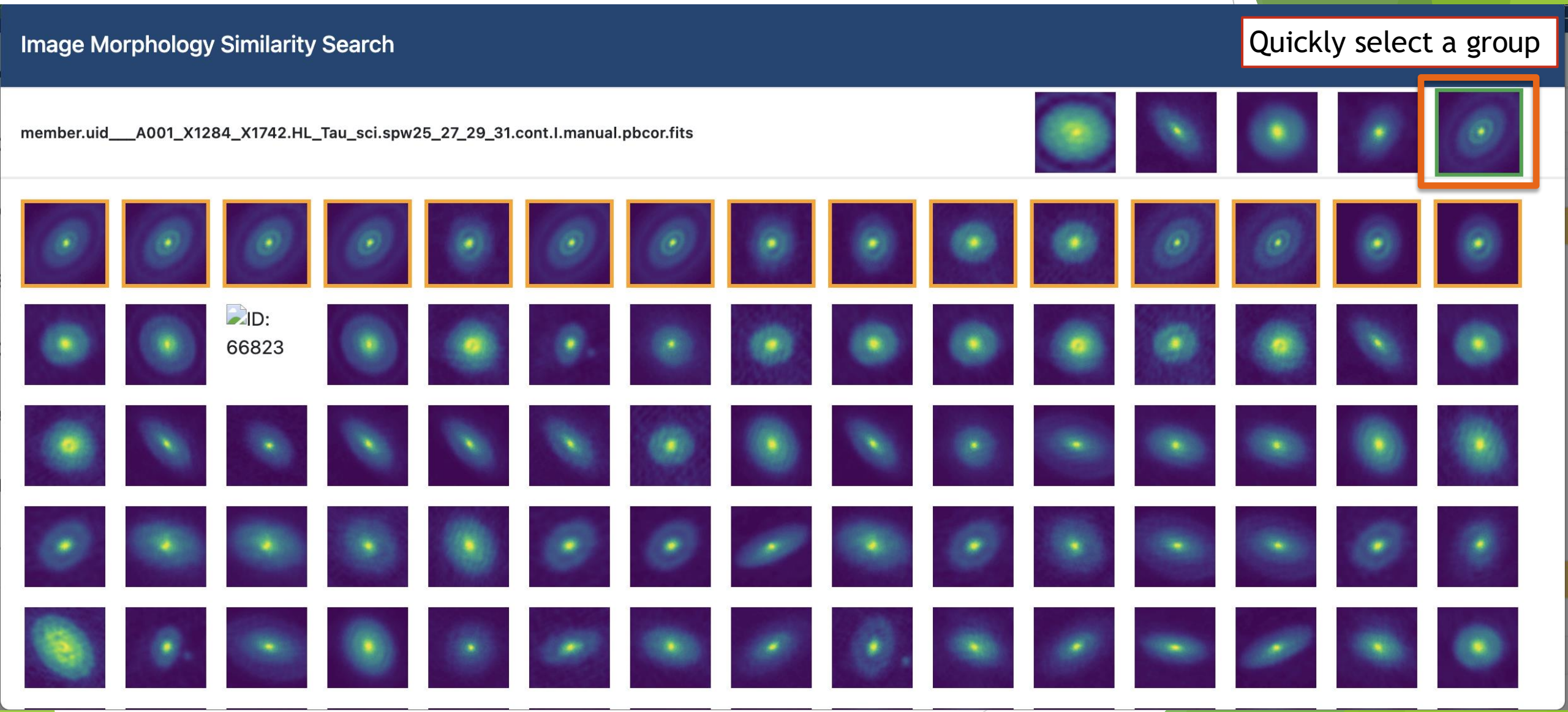
ALMA Archive



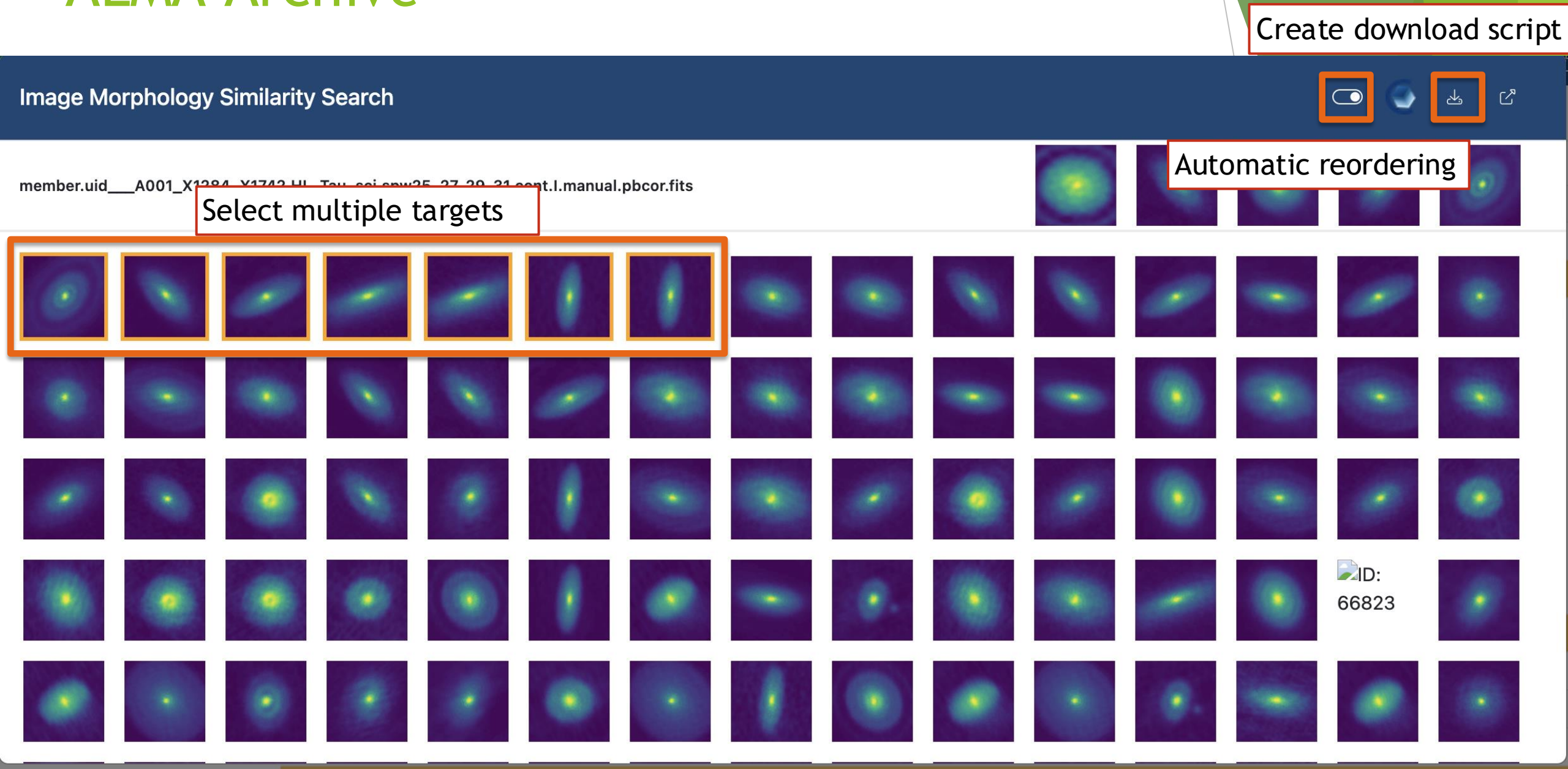
ALMA Archive



ALMA Archive

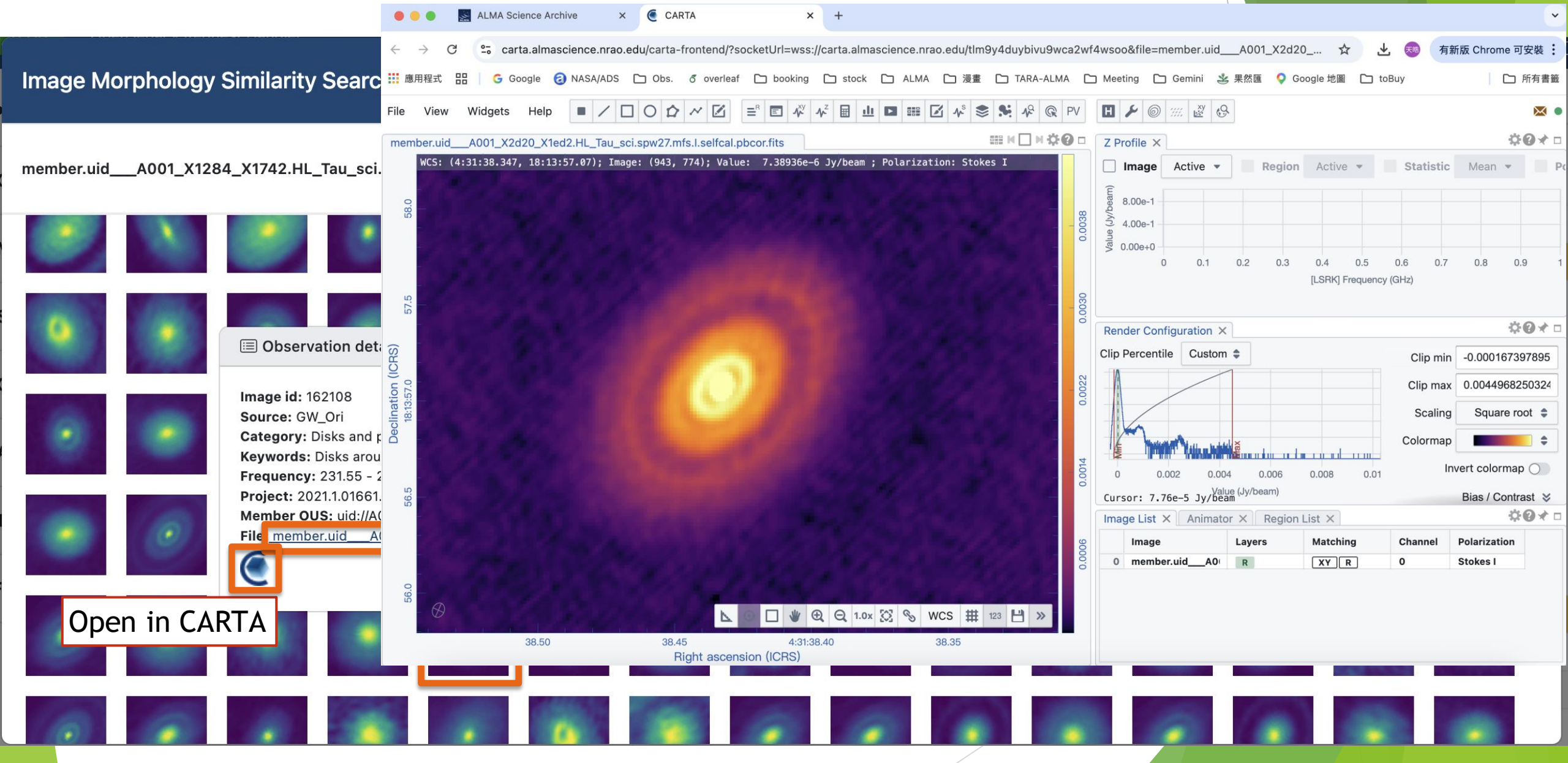


ALMA Archive

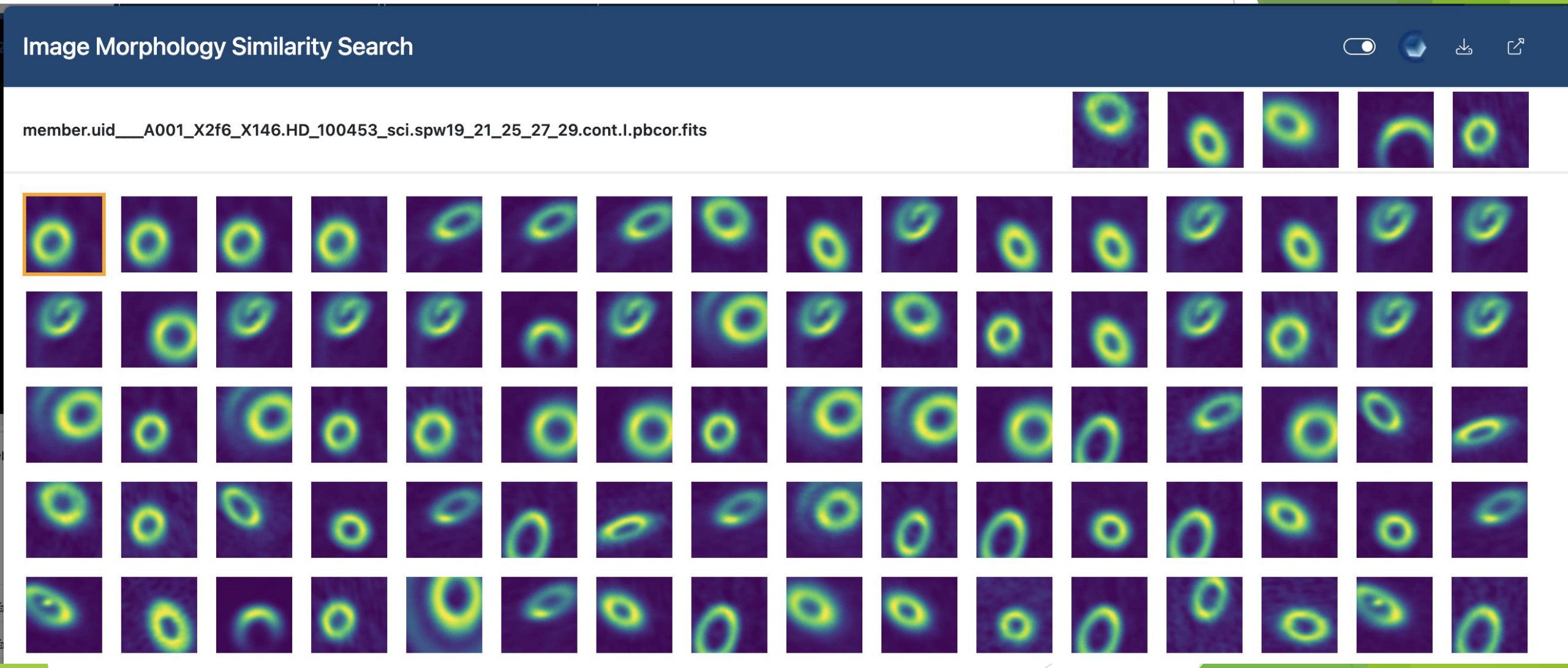


ALMA Archive

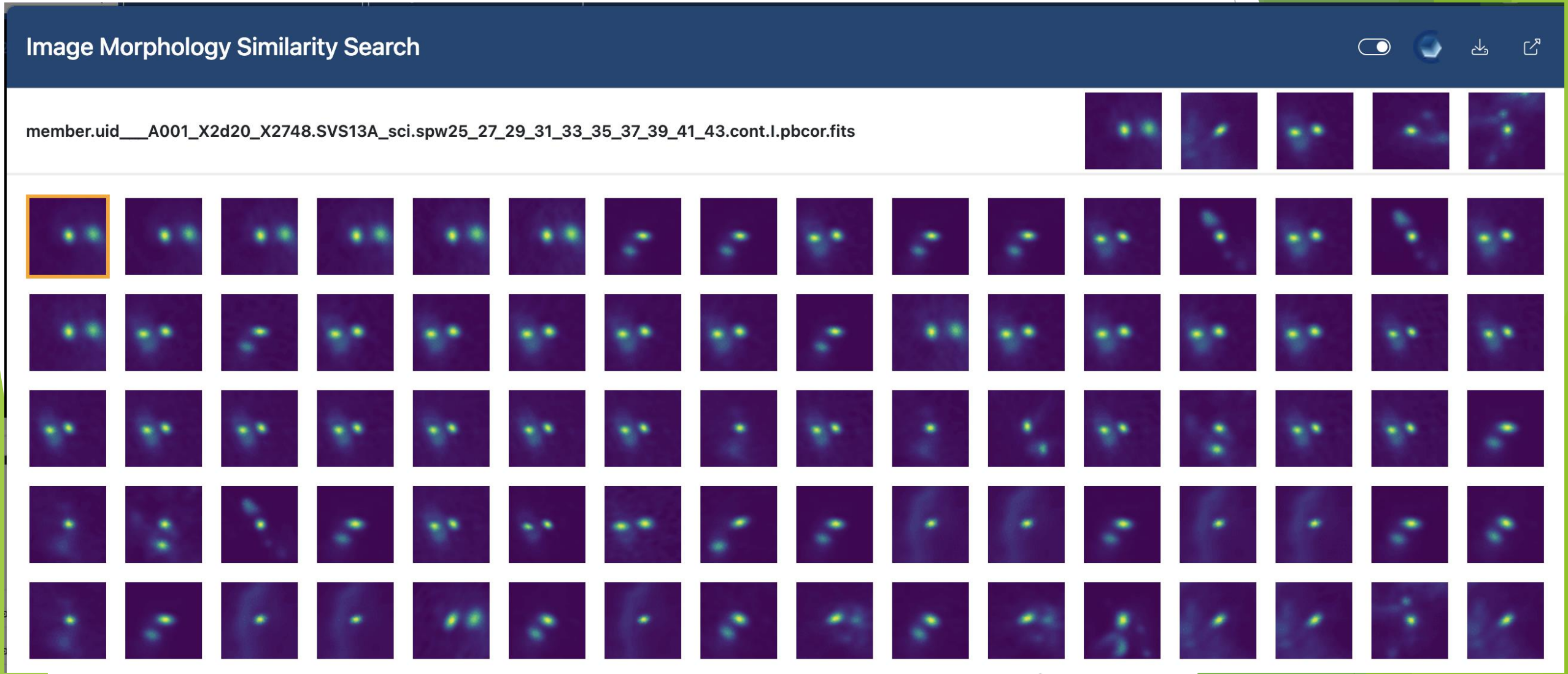
ALMA Archive



ALMA Archive



ALMA Archive



Task

- Find your favorite source or randomly pick one
- Search the source in ALMA archive page
- Find a continuum image
  ex. XXXX.cont.I.pbcor.fits
- Explore the Similarity
- Can you find some similar target?

Thanks for your attention