

Introduction to CASA

Common Astronomy Software Application

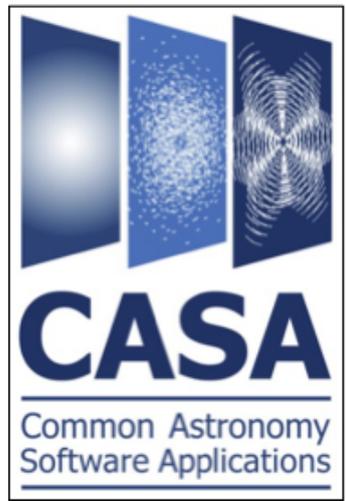
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The University of Manchester



What is CASA?

Common Astronomy Software Applications



- Used for calibration, imaging and analysis of interferometric data
- Used via the command line using an iPython interface
- Available for Linux and Mac OS
- Current general version is CASA 6.6.6
- Current pipeline version is CASA 6.6.1 (this is what we will use)
- Latest and previous releases can always be found here: https://casa.nrao.edu/casa_obtaining.shtml

Launching CASA

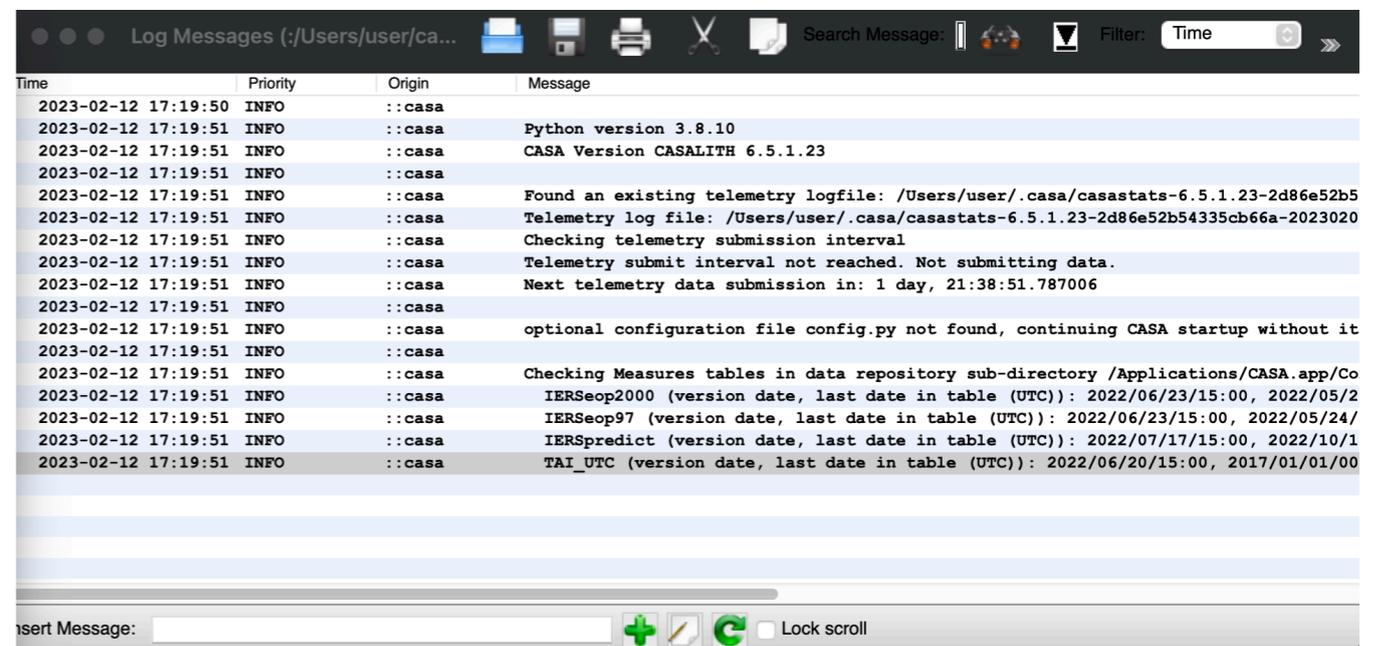
- If you have set up an alias, simply type `casa` on the command line. Otherwise, enter the full path, e.g.:

`~/path-to-casa/bin/casa`

`~/CASA.app/Contents/MacOS/casa`

- This will launch the IPython session in the terminal, along with the CASA logger GUI:

```
user — IPython: Users/user — casalogger < Python -m casashell — 7...
~ — IPython: Users/user — casalogger < Python -m casashell
(base) Dans-Macbook-Pro:~ g25238dw$ casa
optional configuration file config.py not found, continuing CASA startup without it
IPython 7.33.0 -- An enhanced Interactive Python.
Using matplotlib backend: MacOSX
Telemetry initialized. Telemetry will send anonymized usage statistics to NRAO.
You can disable telemetry by adding the following line to the config.py file in your rcdir (e.g. ~/.casa/config.py):
telemetry_enabled = False
--> CrashReporter initialized.
CASA 6.5.1.23 -- Common Astronomy Software Applications [6.5.1.23]
CASA <1>:
```



The screenshot shows the CASA logger GUI window titled "Log Messages (/Users/user/ca...". It features a search bar, a filter dropdown set to "Time", and a scrollable log area. The log contains the following entries:

Time	Priority	Origin	Message
2023-02-12 17:19:50	INFO	::casa	
2023-02-12 17:19:51	INFO	::casa	Python version 3.8.10
2023-02-12 17:19:51	INFO	::casa	CASA Version CASALITH 6.5.1.23
2023-02-12 17:19:51	INFO	::casa	
2023-02-12 17:19:51	INFO	::casa	Found an existing telemetry logfile: /Users/user/.casa/casastats-6.5.1.23-2d86e52b5
2023-02-12 17:19:51	INFO	::casa	Telemetry log file: /Users/user/.casa/casastats-6.5.1.23-2d86e52b54335cb66a-2023020
2023-02-12 17:19:51	INFO	::casa	Checking telemetry submission interval
2023-02-12 17:19:51	INFO	::casa	Telemetry submit interval not reached. Not submitting data.
2023-02-12 17:19:51	INFO	::casa	Next telemetry data submission in: 1 day, 21:38:51.787006
2023-02-12 17:19:51	INFO	::casa	
2023-02-12 17:19:51	INFO	::casa	optional configuration file config.py not found, continuing CASA startup without it
2023-02-12 17:19:51	INFO	::casa	
2023-02-12 17:19:51	INFO	::casa	Checking Measures tables in data repository sub-directory /Applications/CASA.app/Co
2023-02-12 17:19:51	INFO	::casa	IERSeop2000 (version date, last date in table (UTC)): 2022/06/23/15:00, 2022/05/2
2023-02-12 17:19:51	INFO	::casa	IERSeop97 (version date, last date in table (UTC)): 2022/06/23/15:00, 2022/05/24/
2023-02-12 17:19:51	INFO	::casa	IERSpredict (version date, last date in table (UTC)): 2022/07/17/15:00, 2022/10/1
2023-02-12 17:19:51	INFO	::casa	TAI.UTC (version date, last date in table (UTC)): 2022/06/20/15:00, 2017/01/01/00

Tip: use `casa --nologger` if you don't need the logger GUI

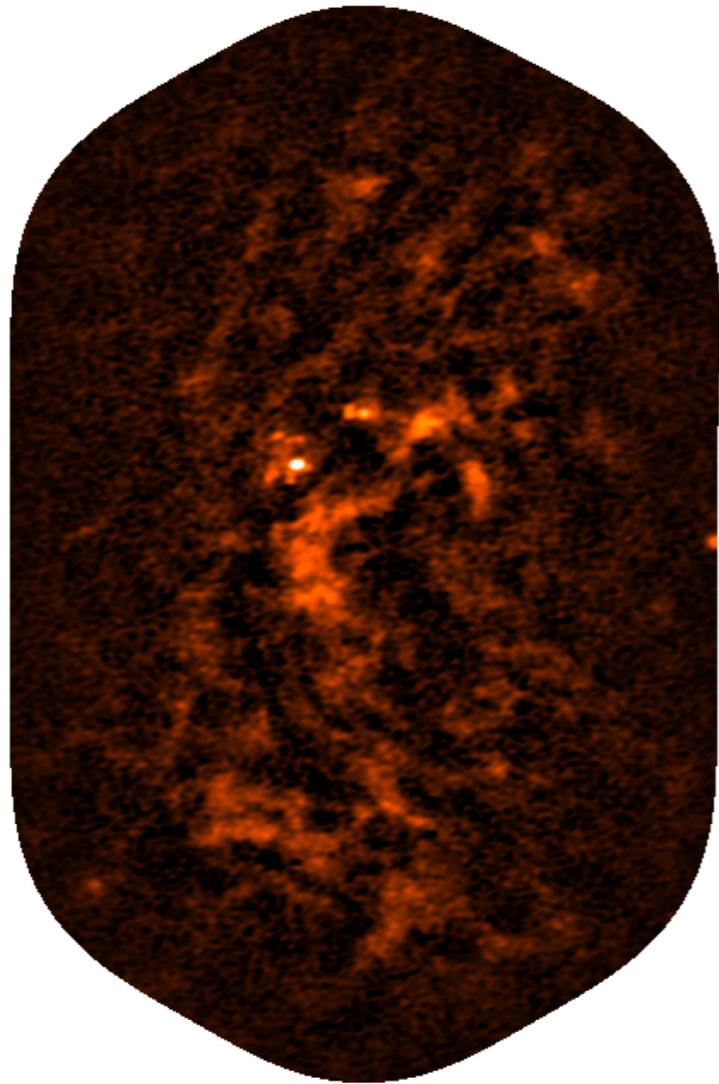
CASA tasks

- CASA tasks are an interface to the underlying toolkit
- Tasks perform a single job such as loading or plotting data
- Each task contains a set of user-defined parameters
- A complete list of available tasks can be found here: <https://casadocs.readthedocs.io/en/stable/api/casatasks.html>
- Example: change the coordinate system of an image using `imregrid`

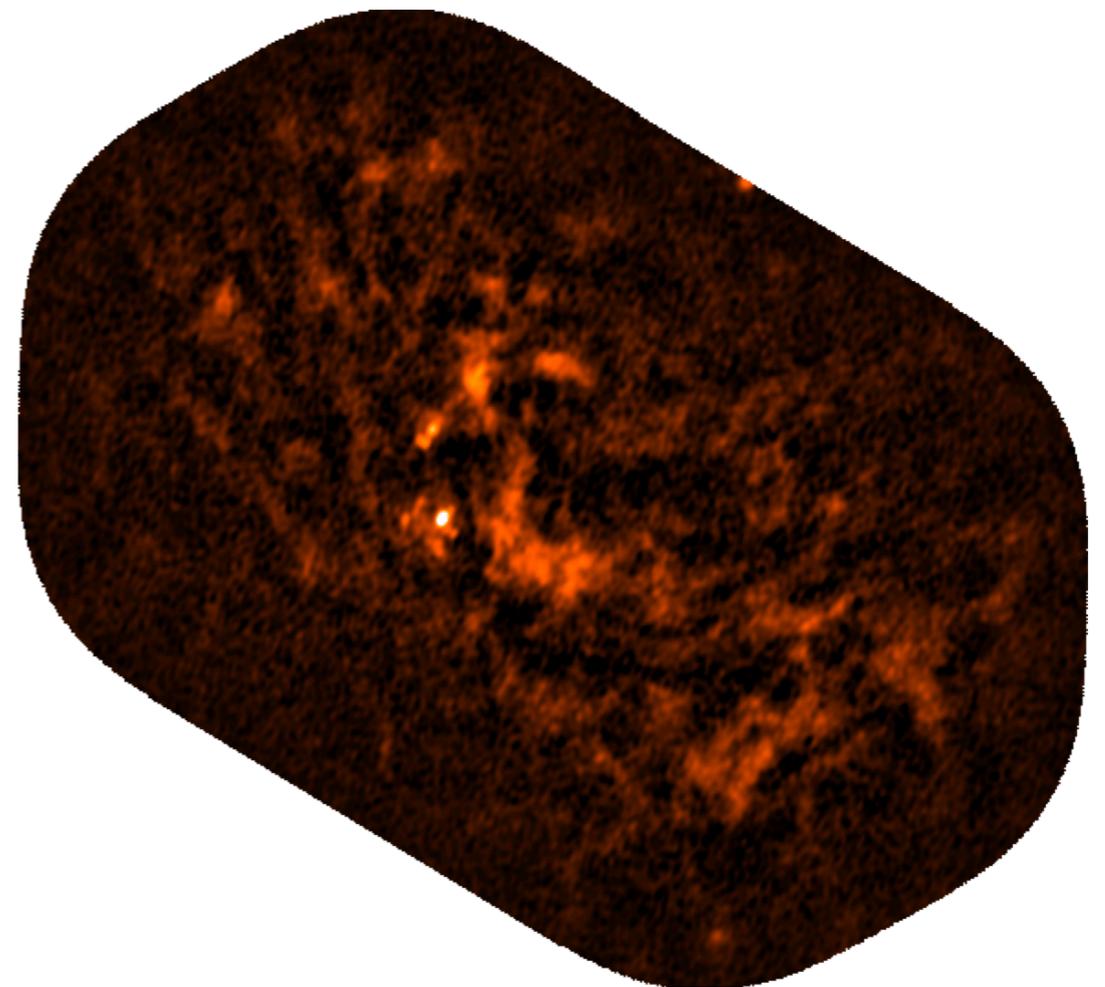
```
imregrid(imagename = 'input_image.fits',  
         template   = 'GALACTIC',  
         output     = 'output_image.galactic')
```

imregrid task example

Input: J2000



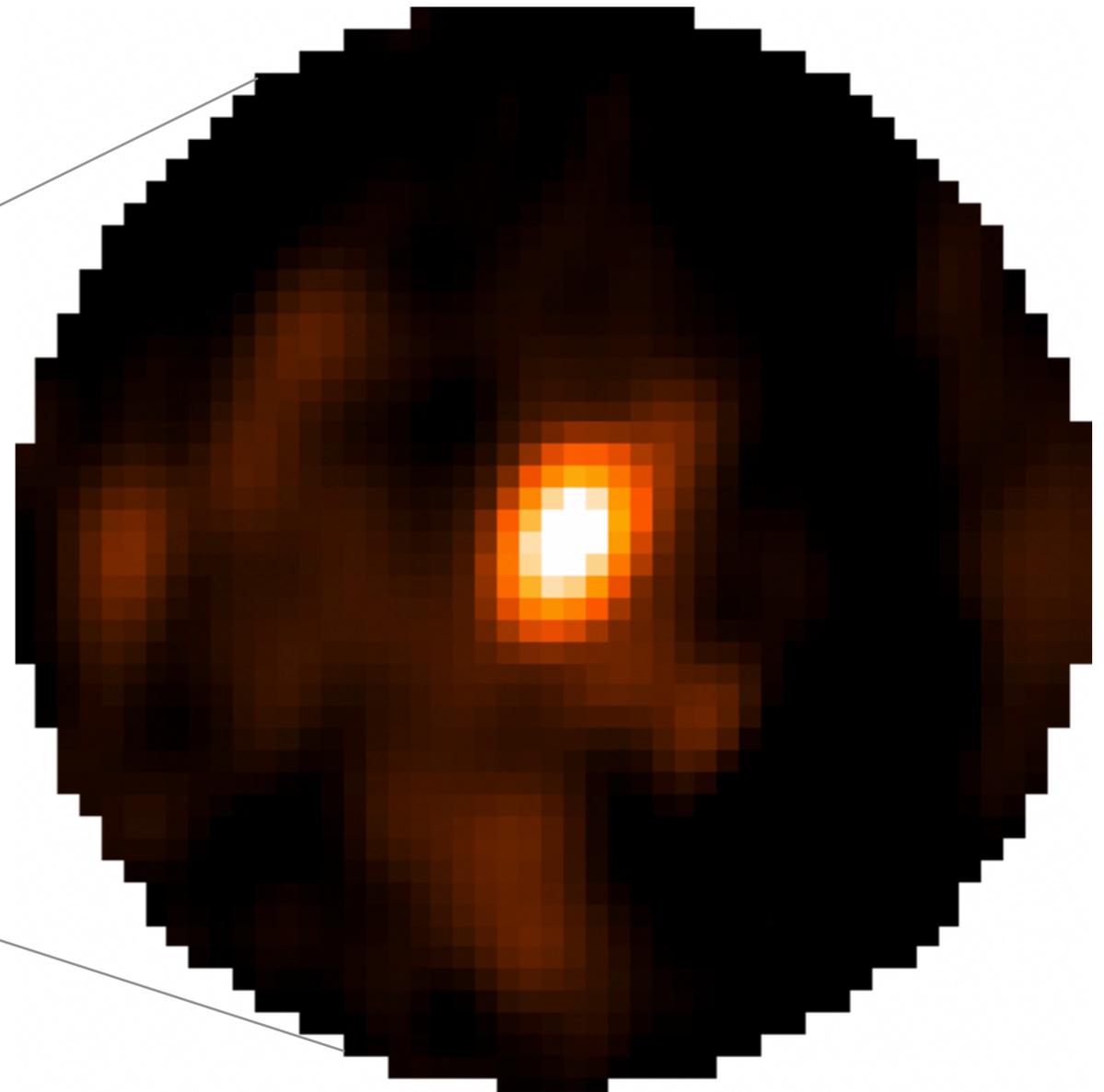
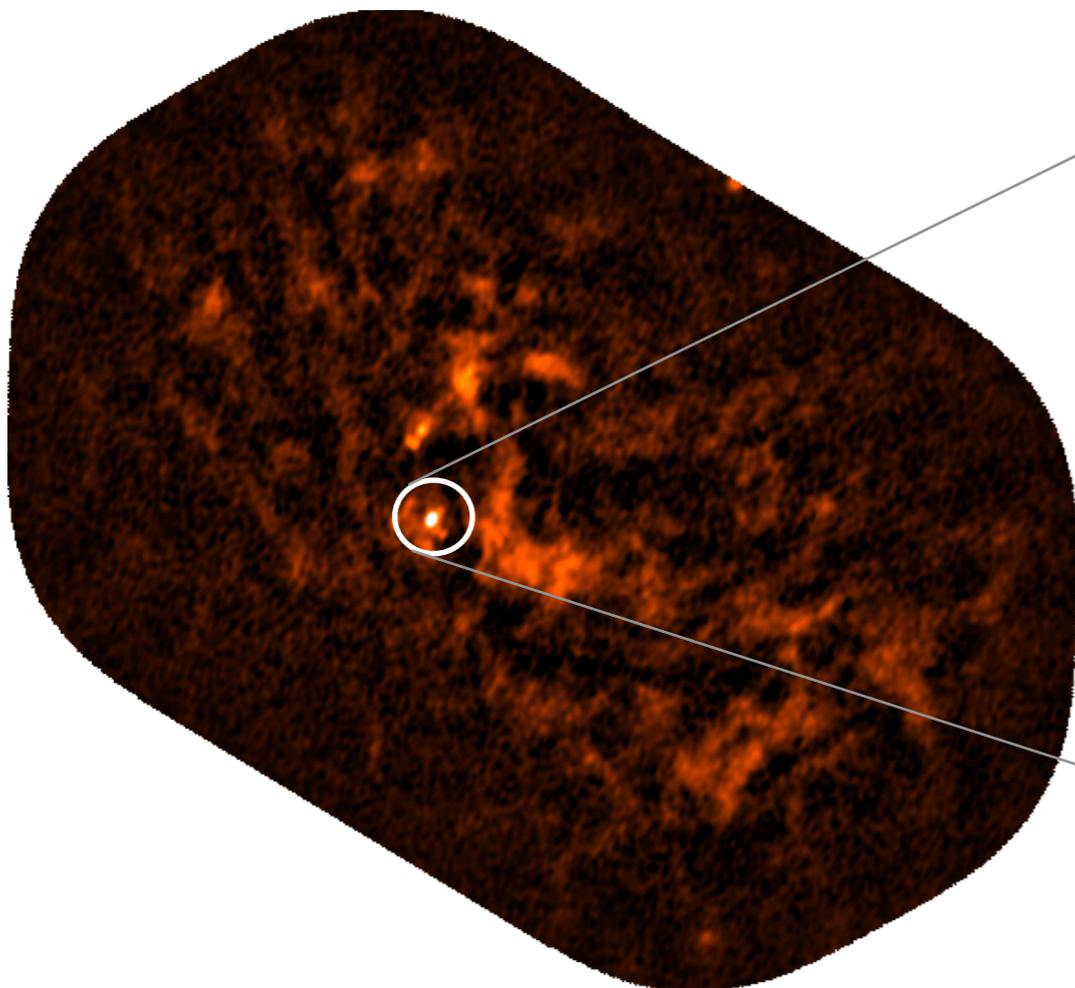
Output: Galactic



imsubimage task example

```
imsubimage(  
  imagename = 'input_image.fits',  
  region    = 'crop_region.crtf',  
  output    = 'output_image')
```

Note: .crtf extension means 'casa region text format' (see [here](#))



CASA tasks

- You can also specify the parameters in turn, and run the task later:

```
default(imregrid)

imagenname = 'input_image.fits'

template   = 'GALACTIC'

output     = 'output_image.galactic'

imregrid()
```

Beware! This method defines parameters globally, so be sure to run `default(task)` for other tasks to avoid potential issues.

CASA tasks

- You can also use tasks in a Python script, which can be executed with CASA. This is good practice for keeping track of your analyses, and making your work repeatable/reproducible.
- **Within CASA:** `execfile(script_name.py)`
- **In terminal:** `casa -c script_name.py`
- **Script example:**

```
import glob

fns = [x for x in glob.glob('*.fits')]

for fn in fns:

    imregrid(imagename = fn, template='GALACTIC',
             output=fn.replace('.fits', '.galactic'))
```

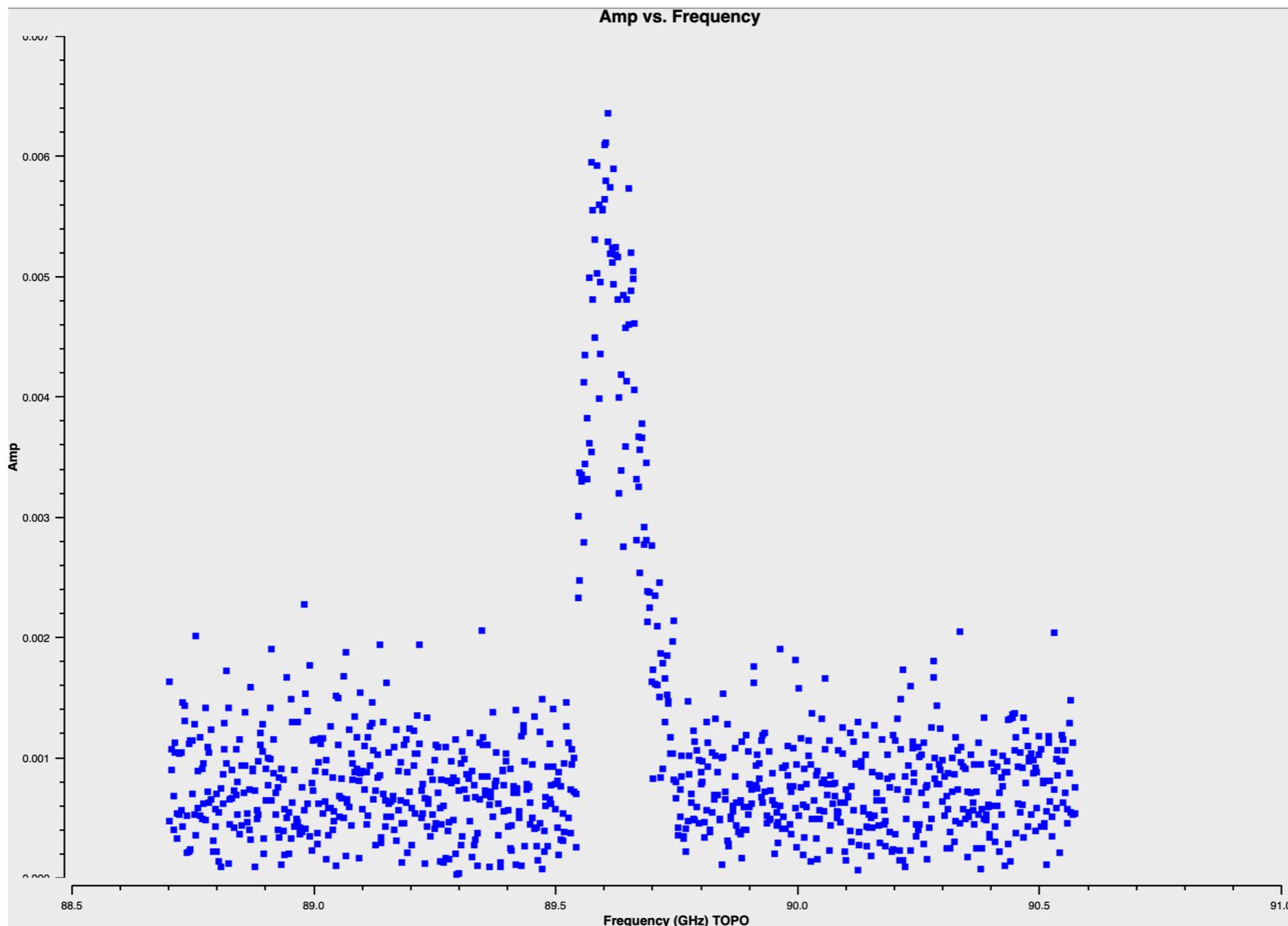
CASA tasks: *listobs*

- Use to inspect key details of the observation and setup
- Live view in casa logger, or output to text file

Time	Priority	Origin	Message
2024-02-18 20:04:21	INFO	...obs:::casa	#####
2024-02-18 20:04:21	INFO	...obs:::casa	##### Begin Task: listobs #####
2024-02-18 20:04:21	INFO	...obs:::casa	listobs(vis='/Users/user/UK_ALMA_Workshop_24/imaging/uid__A002_Xf396d6_X45bb.target.ms', selectdata=True, spw='', field='', antenna='', uvrange='', timerange='')
2024-02-18 20:04:21	INFO	...ms::summary	=====
2024-02-18 20:04:21	INFO	...s::summary+	MeasurementSet Name: /Users/user/UK_ALMA_Workshop_24/imaging/uid__A002_Xf396d6_X45bb.target.ms MS Version 2
2024-02-18 20:04:21	INFO	...s::summary+	=====
2024-02-18 20:04:21	INFO	...s::summary+	Observer: pkamieneski Project: uid://A001/X1525/X705
2024-02-18 20:04:21	INFO	...s::summary+	Observation: ALMA
2024-02-18 20:04:21	INFO	...Properties	Computing scan and subscan properties...
2024-02-18 20:04:35	INFO	...ms::summary	Data records: 42631006 Total elapsed time = 3033.5 seconds
2024-02-18 20:04:35	INFO	...s::summary+	Observed from 04-Dec-2021/12:31:58.1 to 04-Dec-2021/13:22:31.6 (UTC)
2024-02-18 20:04:35	INFO	...ms::summary	=====
2024-02-18 20:04:35	INFO	...s::summary+	ObservationID = 0 ArrayID = 0
2024-02-18 20:04:35	INFO	...s::summary+	Date Timerange (UTC) Scan FldId FieldName nRows SpwIds Average Interval(s) ScanIntent
2024-02-18 20:04:35	INFO	...s::summary+	04-Dec-2021/12:31:58.1 - 12:32:15.3 6 0 PJ113921.7 321172 [4,13,14,15,16,17,18,19,20,21,22,23,24] [1.15, 0.016, 0.016, 0.016, 0.016]
2024-02-18 20:04:35	INFO	...s::summary+	12:32:20.0 - 12:37:23.1 7 0 PJ113921.7 5003098 [4,13,14,15,16,17,18,21,22,23,24,25,26] [1.15, 0.016, 0.016, 0.016, 0.016]
2024-02-18 20:04:35	INFO	...s::summary+	12:38:17.1 - 12:43:19.9 9 0 PJ113921.7 5003052 [4,13,14,15,16,17,18,21,22,23,24,25,26] [1.15, 0.016, 0.016, 0.016, 0.016]
2024-02-18 20:04:35	INFO	...s::summary+	12:44:15.4 - 12:44:34.1 11 0 PJ113921.7 321172 [4,13,14,15,16,17,18,19,20,21,22,23,24] [1.15, 0.016, 0.016, 0.016, 0.016]
2024-02-18 20:04:35	INFO	...s::summary+	12:44:39.6 - 12:49:42.2 12 0 PJ113921.7 5003052 [4,13,14,15,16,17,18,21,22,23,24,25,26] [1.15, 0.016, 0.016, 0.016, 0.016]
2024-02-18 20:04:35	INFO	...s::summary+	12:50:35.5 - 12:55:38.7 14 0 PJ113921.7 5003098 [4,13,14,15,16,17,18,21,22,23,24,25,26] [1.15, 0.016, 0.016, 0.016, 0.016]
2024-02-18 20:04:35	INFO	...s::summary+	12:56:33.8 - 12:56:50.1 16 0 PJ113921.7 321172 [4,13,14,15,16,17,18,19,20,21,22,23,24] [1.15, 0.016, 0.016, 0.016, 0.016]
2024-02-18 20:04:35	INFO	...s::summary+	12:56:58.0 - 13:02:01.1 17 0 PJ113921.7 5003098 [4,13,14,15,16,17,18,21,22,23,24,25,26] [1.15, 0.016, 0.016, 0.016, 0.016]
2024-02-18 20:04:35	INFO	...s::summary+	13:02:55.1 - 13:07:57.9 19 0 PJ113921.7 5003052 [4,13,14,15,16,17,18,21,22,23,24,25,26] [1.15, 0.016, 0.016, 0.016, 0.016]
2024-02-18 20:04:35	INFO	...s::summary+	13:08:52.2 - 13:09:10.1 21 0 PJ113921.7 321126 [4,13,14,15,16,17,18,19,20,21,22,23,24] [1.15, 0.016, 0.016, 0.016, 0.016]
2024-02-18 20:04:35	INFO	...s::summary+	13:09:15.3 - 13:14:18.1 22 0 PJ113921.7 5003052 [4,13,14,15,16,17,18,21,22,23,24,25,26] [1.15, 0.016, 0.016, 0.016, 0.016]
2024-02-18 20:04:35	INFO	...s::summary+	13:15:12.4 - 13:20:15.1 24 0 PJ113921.7 5003052 [4,13,14,15,16,17,18,21,22,23,24,25,26] [1.15, 0.016, 0.016, 0.016, 0.016]
2024-02-18 20:04:35	INFO	...s::summary+	13:21:08.4 - 13:21:25.6 26 0 PJ113921.7 321172 [4,13,14,15,16,17,18,19,20,21,22,23,24] [1.15, 0.016, 0.016, 0.016, 0.016]
2024-02-18 20:04:35	INFO	...s::summary+	13:21:30.2 - 13:22:31.6 27 0 PJ113921.7 1000638 [4,13,14,15,16,17,18,21,22,23,24,25,26] [1.15, 0.016, 0.016, 0.016, 0.016]
2024-02-18 20:04:35	INFO	...ms::summary	(nRows = Total number of rows per scan)
2024-02-18 20:04:35	INFO	...ms::summary	Fields: 1
2024-02-18 20:04:35	INFO	...s::summary+	ID Code Name RA Decl Epoch SrcId nRows
2024-02-18 20:04:35	INFO	...s::summary+	0 none PJ113921.7 11:39:21.742000 +20.24.50.90000 ICRS 0 42631006
2024-02-18 20:04:35	INFO	...ms::summary	Spectral Windows: (15 unique spectral windows and 2 unique polarization setups)
2024-02-18 20:04:35	INFO	...s::summary+	SpwID Name #Chans Frame Ch0 (MHz) ChanWid(kHz) TotBW(kHz) CtrFreq(MHz) BBC Num Corrs
2024-02-18 20:04:35	INFO	...s::summary+	4 WVR#NOMINAL 4 TOPO 184550.000 1500000.000 7500000.0 187550.0000 0 XX
2024-02-18 20:04:35	INFO	...s::summary+	13 X1620027342#ALMA_RB_03#BB_1#SQLD 1 TOPO 87878.312 2000000.000 2000000.0 87878.3124 1 XX YY
2024-02-18 20:04:35	INFO	...s::summary+	14 X1620027342#ALMA_RB_03#BB_2#SQLD 1 TOPO 89639.062 2000000.000 2000000.0 89639.0616 2 XX YY
2024-02-18 20:04:35	INFO	...s::summary+	15 X1620027342#ALMA_RB_03#BB_3#SQLD 1 TOPO 10062.031 2000000.000 2000000.0 10062.0312 3 XX YY
2024-02-18 20:04:35	INFO	...s::summary+	16 X1620027342#ALMA_RB_03#BB_4#SQLD 1 TOPO 101618.562 2000000.000 2000000.0 101618.5616 4 XX YY
2024-02-18 20:04:35	INFO	...s::summary+	17 X1620027342#ALMA_RB_03#BB_1#SW-01#FULL_RES 128 TOPO 88870.500 -15625.000 2000000.0 87878.3124 1 XX YY
2024-02-18 20:04:35	INFO	...s::summary+	18 X1620027342#ALMA_RB_03#BB_1#SW-01#CH_AVG 1 TOPO 87862.687 1796875.000 1796875.0 87862.6874 1 XX YY
2024-02-18 20:04:35	INFO	...s::summary+	19 X1620027342#ALMA_RB_03#BB_2#SW-01#FULL_RES 128 TOPO 90631.249 -15625.000 2000000.0 89639.0616 2 XX YY
2024-02-18 20:04:35	INFO	...s::summary+	20 X1620027342#ALMA_RB_03#BB_2#SW-01#CH_AVG 1 TOPO 89631.249 1875000.000 1875000.0 89631.2491 2 XX YY
2024-02-18 20:04:35	INFO	...s::summary+	21 X1620027342#ALMA_RB_03#BB_3#SW-01#FULL_RES 128 TOPO 99069.844 15625.000 2000000.0 10062.0312 3 XX YY
2024-02-18 20:04:35	INFO	...s::summary+	22 X1620027342#ALMA_RB_03#BB_3#SW-01#CH_AVG 1 TOPO 100046.406 1796875.000 1796875.0 100046.4062 3 XX YY
2024-02-18 20:04:35	INFO	...s::summary+	23 X1620027342#ALMA_RB_03#BB_4#SW-01#FULL_RES 128 TOPO 100626.374 15625.000 2000000.0 101618.5616 4 XX YY
2024-02-18 20:04:35	INFO	...s::summary+	24 X1620027342#ALMA_RB_03#BB_4#SW-01#CH_AVG 1 TOPO 101602.937 1796875.000 1796875.0 101602.9366 4 XX YY
2024-02-18 20:04:35	INFO	...s::summary+	25 X1620027342#ALMA_RB_03#BB_2#SW-01#FULL_RES 480 TOPO 90574.608 -3906.250 1875000.0 89639.0616 2 XX YY
2024-02-18 20:04:35	INFO	...s::summary+	26 X1620027342#ALMA_RB_03#BB_2#SW-01#CH_AVG 1 TOPO 89638.817 1875000.000 1875000.0 89638.8175 2 XX YY
2024-02-18 20:04:35	INFO	...ms::summary	Sources: 15
2024-02-18 20:04:35	INFO	...s::summary+	ID Name SpwID RestFreq(MHz) SysVel(km/s)
2024-02-18 20:04:35	INFO	...s::summary+	0 PJ113921.7 4

CASA tasks: *plotms*

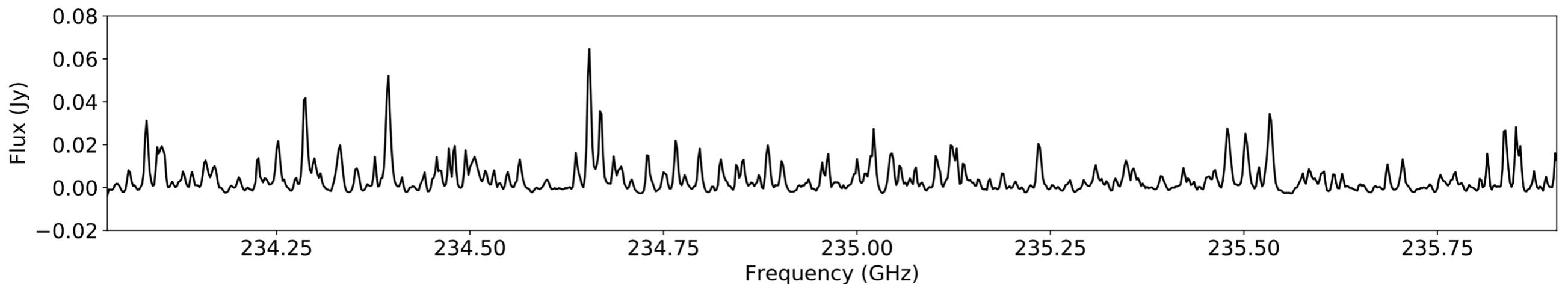
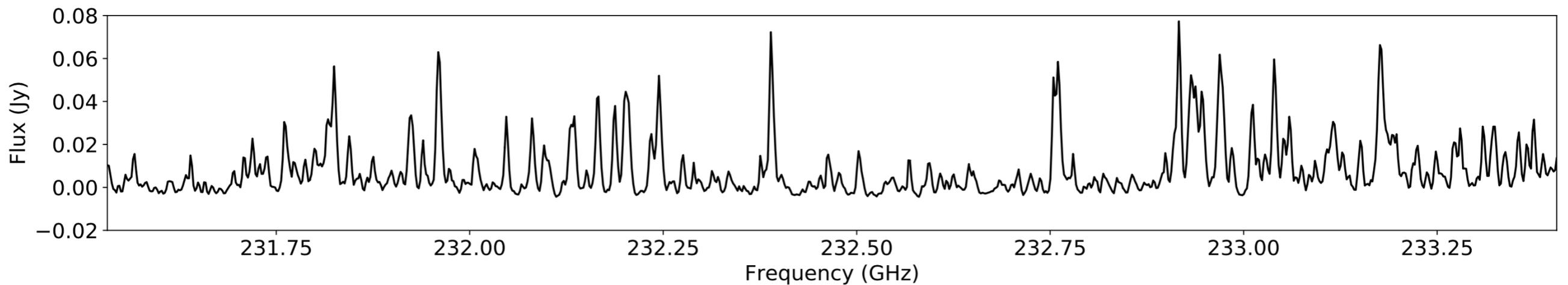
- Use to plot and interact with visibility data
- Critical for calibration and flagging stages of data reduction



[Link to full documentation](#)

CASA tasks

- Finding and flagging line emission is critical, but can be extremely difficult in line-rich regions (e.g. Galactic centre high-mass SF region below)
- These cases typically need more automated methods



CASA tasks & Python

- You can easily install Python packages within CASA so that you can use CASA tasks and e.g. `astropy` together
 - Simply type e.g. `pip install astropy` inside a CASA session
- Alternatively, you can install CASA tasks and tools in your Python environment:
 - <https://casadocs.readthedocs.io/en/stable/notebooks/introduction.html#Modular-Packages>

CASA data formats

- Raw visibility (uv) data from ALMA comes in *ALMA Science Data Model (ASDM)* format
- Once imported into CASA this is stored as a Measurement Set (*MS*)
- These are structured as directories containing many (sub-)tables, *not* individual files, e.g.:
- Any image files produced by a CASA task will also be stored in this format
- Use task `exportfits` to convert CASA image files to FITS format

```
dwalker2@iris3 /raid/dwalker2/UK_workshop/uid__A002_Xf396d6_X45bb.ms > ls
ANTENNA                POINTING                table.f17                table.f23_TSM1
ASDM_ANNOTATION        POLARIZATION            table.f17_TSM1           table.f23_TSM2
ASDM_ANTENNA           PROCESSOR                table.f17_TSM2           table.f24
ASDM_CALATMOSPHERE     SOURCE                   table.f17_TSM3           table.f24_TSM1
ASDM_CALPOINTING       Source.xml               table.f17_TSM4           table.f24_TSM2
ASDM_CALWVR            SPECTRAL_WINDOW         table.f18                 table.f24_TSM3
ASDM_EXECBLOCK         SpectralWindow.xml      table.f19                 table.f24_TSM4
ASDM_RECEIVER          STATE                    table.f2                   table.f3
ASDM_SBSUMMARY         SYSCAL                   table.f20                 table.f4
ASDM_SOURCE            SYSPower                 table.f20_TSM0           table.f5
ASDM_STATION           table.dat                table.f21                 table.f6
CALDEVICE              table.f1                 table.f21_TSM1           table.f7
DATA_DESCRIPTION       table.f10                table.f21_TSM2           table.f8
DataDescription.xml    table.f11                table.f21_TSM3           table.f9
FEED                   table.f12                table.f21_TSM4           table.info
FIELD                  table.f13                table.f22                 table.lock
FLAG_CMD               table.f14                table.f22_TSM1           WEATHER
HISTORY                table.f15                table.f22_TSM2
OBSERVATION            table.f16                table.f23
```

Getting help with CASA

- Type `inp taskname` to get an overview of a given task and its input parameters

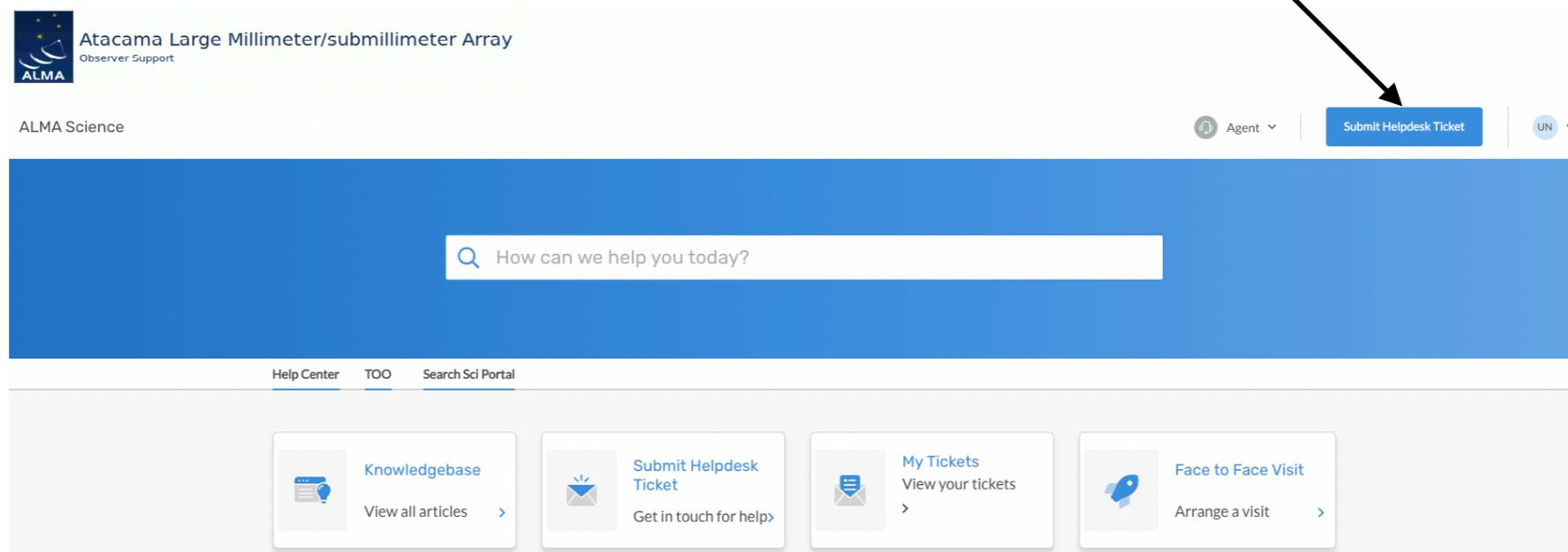
```
CASA <4>: inp imregrid
# imregrid -- regrid an image onto a template image
imagenam     = ''                               # Name of the source image
             'get'                             # A dictionary, refcode, or name of an image that provides the output
             'get'                             # shape and coordinate system
output       = ''                               # Name for the regridded image
asvelocity   = True                            # Regrid spectral axis in velocity space rather than frequency space?
axes         = [-1]                            # The pixel axes to regrid. -1 => all.
interpolation = 'linear'                       # The interpolation method. One of "nearest", "linear", "cubic".
decimate     = 10                              # Decimation factor for coordinate grid computation
replicate    = False                           # Replicate image rather than regrid?
overwrite    = False                           # Overwrite (unprompted) pre-existing output file?
```

- Type `help taskname` to get a detailed description of a given task and its input parameters (use arrow keys to continue, press q to exit)

```
Help on _imregrid in module casashell.private.imregrid object:
class _imregrid(builtins.object)
|   imregrid ---- regrid an image onto a template image
|
|   Imregrid will regrid an input image onto a new coordinate system from a template image
|   or to a new directional reference frame. If a template image is used, then the input and
|   template images must have the same coordinate structure.
|
|   ----- parameter descriptions -----
|
|   imagenam     Name of the source image
|   template     A dictionary, refcode, or name of an image that provides the output shape and coordinate system
|   output       Name for the regridded image
|   asvelocity   Regrid spectral axis in velocity space rather than frequency space?
|
```

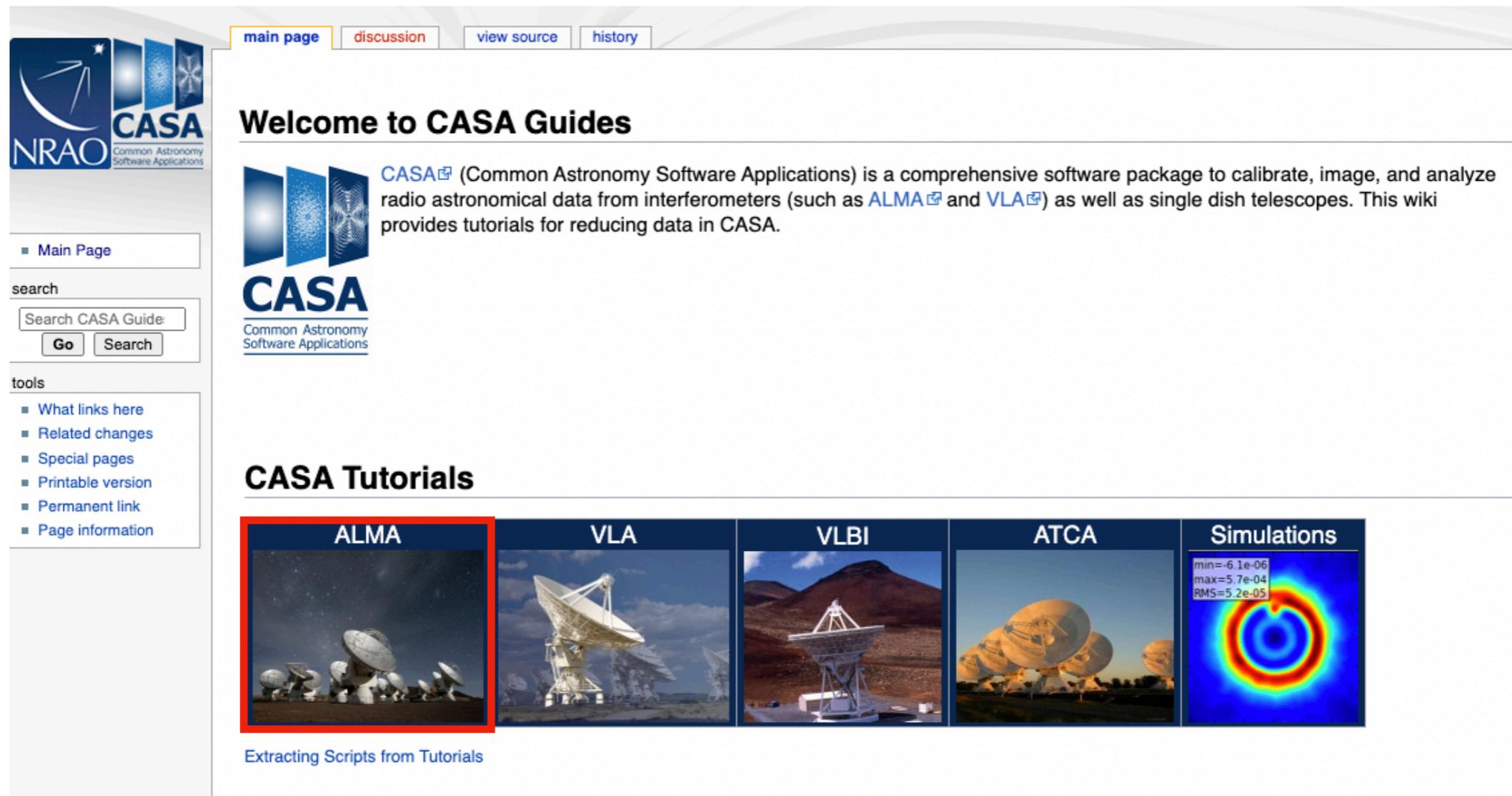
Getting help with CASA

- For the most detailed information, refer to the latest CASA documentation: <https://casa.nrao.edu/casadocs/latest>
- If you are still having issues, you can submit a Helpdesk ticket, and someone will happily assist you!
- Visit <https://help.almascience.org/>
- Submit to the Data Reduction department
- State CASA version and OS



CASA Guides

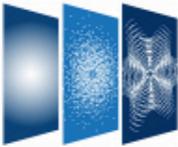
- Go to https://casaguides.nrao.edu/index.php?title=Main_Page for a suite of examples to guide you through using some CASA tasks (mostly imaging related).



The screenshot shows the main page of the CASA Guides website. At the top, there is a navigation bar with links for "main page", "discussion", "view source", and "history". The main heading is "Welcome to CASA Guides". Below this, a paragraph describes CASA as a comprehensive software package for calibrating, imaging, and analyzing radio astronomical data from interferometers like ALMA and VLA, as well as single dish telescopes. The page features a sidebar on the left with a search box and a "tools" section containing links for "What links here", "Related changes", "Special pages", "Printable version", "Permanent link", and "Page information". A "CASA Tutorials" section is located at the bottom, displaying five thumbnail images: ALMA, VLA, VLBI, ATCA, and Simulations. The ALMA thumbnail is highlighted with a red border. The Simulations thumbnail includes a color scale legend with values: min=-6.1e-06, max=5.7e-04, and RMS=5.2e-05.

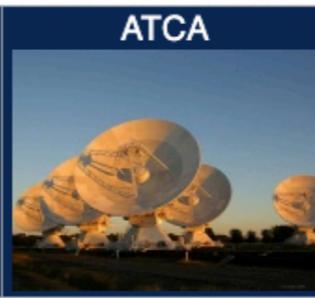
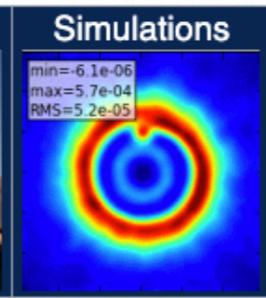
main page discussion view source history

Welcome to CASA Guides

 **CASA** (Common Astronomy Software Applications) is a comprehensive software package to calibrate, image, and analyze radio astronomical data from interferometers (such as [ALMA](#) and [VLA](#)) as well as single dish telescopes. This wiki provides tutorials for reducing data in CASA.

CASA
Common Astronomy Software Applications

CASA Tutorials

ALMA	VLA	VLBI	ATCA	Simulations
				 min=-6.1e-06 max=5.7e-04 RMS=5.2e-05

[Extracting Scripts from Tutorials](#)