CASA on Allegro machines

EUROPEAN ARC
ALMA Regional Centre || Allegro

Logon to the almaportal:

ssh -X *strwname*@almaportal.leidenuniv.nl

Logon to helada (server we will work on):

ssh -X *strwname*@helada

ssh -X *strwname*@tulor

get ‘allegro-setup’

by adding this to your .tshrc

alias allegro-setup 'source /almastorage/allegro/bin/allegro-user-setup.csh'

Go to your data reduction training directory:

```
cd /almastorage/allegro/home/*strwname*/open_ALMA_DRT2023/anlysis/*strwname*
```

Copy data to your area:

```
cp -r ../../archive/DRT2023/TW_hydra/sis14_twhya_calibrated_flagged.ms.contsub ./
```

Launch CASA

nice +10 env -u PYTHONPATH -u LD_LIBRARY_PATH casapy-641p

Common Astronomy Software Applications

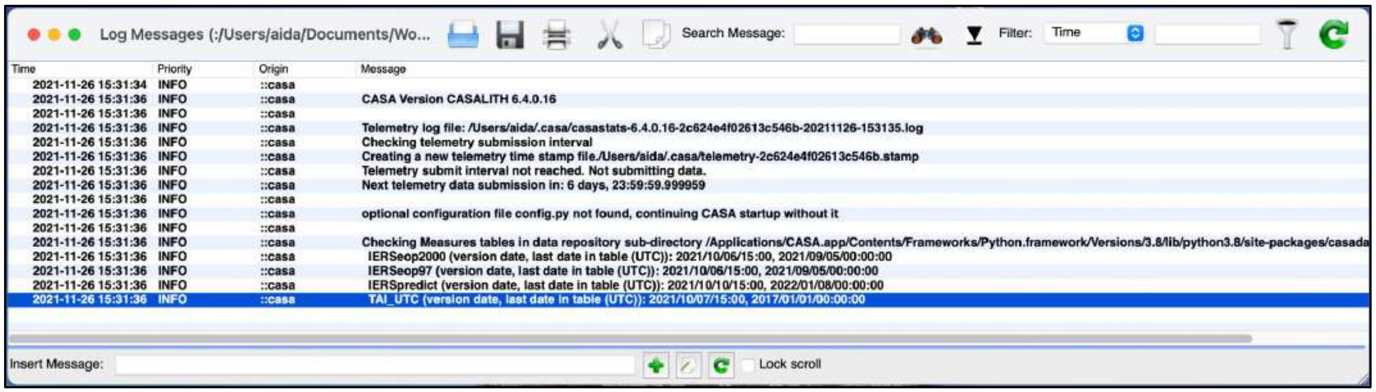
- Can process data from both **single-dish** and **aperture-synthesis telescopes**
- Primary data processing (calibration & imaging) software for **ALMA** & **VLA**
- Python based
  - Versions < 6 use Python 2.7
  - Newer versions use Python 3
- Available for Linux (RedHat) and Mac OS

→ **Website** – https://casa.nrao.edu/
→ **Guides** – https://casaguides.nrao.edu/
→ **Documentation**
  - Versions 6.1 & earlier: https://casa.nrao.edu/casadocs
  - Versions 6.2 & later: https://casadocs.readthedocs.io/en/stable/

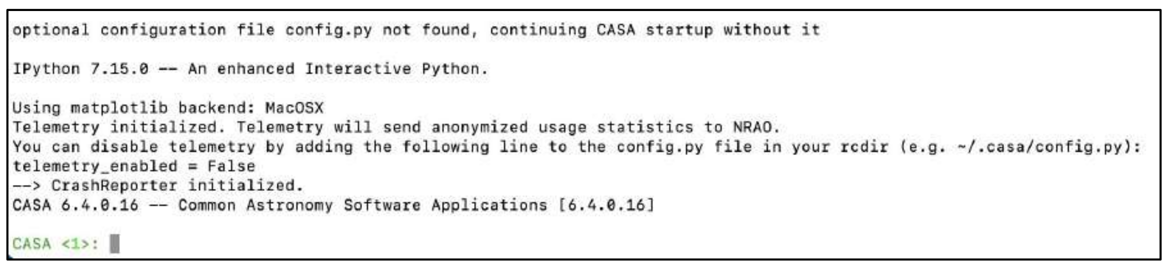
Starting CASA

After installation, to open CASA simply type `casa` in the terminal if you set up an alias. Otherwise type the full path.

➔ Starting CASA will open a logger (and a log file):



➔ And the terminal prompt:



```
optional configuration file config.py not found, continuing CASA startup without it

IPython 7.15.0 -- 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 6.4.0.16 -- Common Astronomy Software Applications [6.4.0.16]

CASA <1>:
```

`casa --nologger`

if you do not need the logger `GUI`

CASA Basics

CASA Tasks

Tasks are executed to perform a single job (e.g. loading, plotting, flagging, calibrating)
Each task contains a set of user-defined parameters

List of available tasks

`taskhelp` -> A more exhaustive list of tasks with descriptions
`tasklist()` -> Get an overview of available tasks, organized by category **(removed in CASA 6)**

+ More information about the tasks:
https://casadocs.readthedocs.io/en/stable/api/casatasks.html

Getting help on a task

`inp <taskname>` to get an overview of a given task and its input parameters

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

Based on: https://casaguides.nrao.edu/index.php?title=Getting_Started_in_CASA

CASA Basics

Executing a task

Interactively:

`tget <taskname>` -> get the task and its previously set parameters
`inp` -> determine the input parameters needed for the task that was set
(set individual parameters using a Python **`<parameter>=<value>`** syntax)
`go` -> run the task

You may also do:

`default(<taskname>)` -> to set the parameters of a task to their default values
set individual parameters using a Python **`<parameter>=<value>`** syntax

Note: *you can also simply set parameters without the* **`default`** *or* **`tget`** *steps but beware that you would be setting parameters globally!*

Programmatically:

```
taskname(parameter1='', parameter2='', ...)
```

Based on: https://casaguides.nrao.edu/index.php?title=Getting_Started_in_CASA

CASA Basics

Parameters

grey: parameter has sub-parameters
green: sub-parameters
red: invalid value
blue: parameter altered from its default

```
CASA <39>: inp tclean
# tclean -- Radio Interferometric Image Reconstruction
vis                 = 'data/sis14_twhya_calibrated_flagged.ms'
                                                  # Name of input visibility file(s)
selectdata          = True                        # Enable data selection parameters
     field          = ''                          # field(s) to select
     spw            = ''                          # spw(s)/channels to select
     timerange      = ''                          # Range of time to select from data
     uvrange        = ''                          # Select data within uvrange
     antenna        = ''                          # Select data based on antenna/baseline
     scan           = ''                          # Scan number range
     observation    = ''                          # Observation ID range
     intent         = ''                          # Scan Intent(s)
datacolumn          = ''                          # Data column to image(data,corrected)
imagename           = ''                          # Pre-name of output images
imsize              = [100]                       # Number of pixels
cell                = []                          # Cell size
phasecenter         = ''                          # Phase center of the image
stokes              = 'I'                         # Stokes Planes to make
projection          = 'SIN'                       # Coordinate projection
startmodel          = ''                          # Name of starting model image
specmode            = 'mfs'                       # Spectral definition mode (mfs,cube,cubedata, cubesource)
     reffreq        = ''                          # Reference frequency
gridder             = 'standard'                  # Gridding options (standard, wproject, widefield, mosaic, awproject)
     vptable        = ''                          # Name of Voltage Pattern table
     pblimit        = 0.2                         # PB gain level at which to cut off normalizations
deconvolver         = 'hogbom'                    # Minor cycle algorithm (hogbom,clark,multiscale,mtmfs,mem,clarkstokes)
restoration         = True                        # Do restoration steps (or not)
     restoringbeam  = []                          # Restoring beam shape to use. Default is the PSF main lobe
     pbcor          = False                       # Apply PB correction on the output restored image
outlierfile         = ''                          # Name of outlier-field image definitions
weighting           = 'nat'                       # Weighting scheme (natural,uniform,briggs, briggsabs[experimental], briggsbwtaper[experimental])
niter               = 0                           # Maximum number of iterations
usemask             = 'user'                      # Type of mask(s) for deconvolution: user, pb, or auto-multithresh
     mask           = ''                          # Mask (a list of image name(s) or region file(s) or region string(s) )
     pbmask         = 0.0                         # primary beam mask
fastnoise           = True                        # True: use the faster (old) noise calculation. False: use the new improved noise calculations
restart             = True                        # True : Re-use existing images. False : Increment imagename
savemodel           = 'none'                      # Options to save model visibilities (none, virtual, modelcolumn)
calcres             = True                        # Calculate initial residual image
calcpsf             = True                        # Calculate PSF
     psfcutoff      = 0.35                        # All pixels in the main lobe of the PSF above psfcutoff are used to fit a Gaussian beam (the Clean beam).
parallel            = False                       # Run major cycles in parallel
```

Data selection syntax

spw='0:5~30;40~55,1:10~25;45~58,2'

Running scripts

In CASA: `execfile('script_name.py')`

In the terminal: `casa -c script_name.py`

Data Inspection with CASA

listobs	list the contents of measurement set
plotants	plot the location of antennas
plotms	inspect/flag visibilities interactively
imview	view/inspect images interactively

listobs: lists the contents of measurement set

Can select a subset of the measurement set

```
CASA <11>: inp listobs
# listobs -- List the summary of a data set in the logger or in a file
vis                 = ''           # Name of input visibility file (MS)
selectdata          = True         # Data selection parameters
     spw            = ''           # Selection based on spectral-window/frequency/channel.
     field          = ''           # Selection based on field names or field index numbers. Default is all.
     antenna        = ''           # Selection based on antenna/baselines. Default is all.
     uvrange        = ''           # Selection based on uv range. Default: entire range. Default units: meters.
     timerange      = ''           # Selection based on time range. Default is entire range.
     correlation    = ''           # Selection based on correlation. Default is all.
     scan           = ''           # Selection based on scan numbers. Default is all.
     intent         = ''           # Selection based on observation intent. Default is all.
     feed           = ''           # Selection based on multi-feed numbers: Not yet implemented
     array          = ''           # Selection based on (sub)array numbers. Default is all.
     observation    = ''           # Selection based on observation ID. Default is all.
verbose             = True         # Controls level of information detail reported. True reports more than False.
listfile            = ''           # Name of disk file to write output. Default is none (output is written to logger only).
listunfl            = False        # List unflagged row counts? If true, it can have significant negative performance impact.
cachesize           = 50.0         # EXPERIMENTAL. Maximum size in megabytes of cache in which data structures can be held.
```

Optionally can write the output to a file

listobs: lists the contents of measurement set

Example > listobs(vis='sis14_twhya_calibrated_flagged.ms')

sequence of observations

```
##########################################
##### Begin Task: listobs          #####
listobs( vis='sis14_twhya_calibrated_flagged.ms', selectdata=True, spw='', field='', antenna='', uvrange='', timerange='', correlation='', scan='', intent='', feed='', array='', observation='', verbose=
================================================================================
           MeasurementSet Name:  /Users/aida/Documents/Work/Leiden/Allegro/Events/202111_Data_Reduction_Day/data/sis14_twhya_calibrated_flagged.ms      MS Version 2
================================================================================
   Observer: cqi     Project: uid://A002/X327408/X6f
Observation: ALMA
Computing scan and subscan properties...
Data records: 80563       Total elapsed time = 5647.68 seconds
   Observed from   19-Nov-2012/07:36:57.0   to   19-Nov-2012/09:11:04.7 (UTC)

   ObservationID = 0         ArrayID = 0
  Date        Timerange (UTC)          Scan  FldId FieldName             nRows     SpwIds   Average Interval(s)    ScanIntent
  19-Nov-2012/07:36:57.0 - 07:39:13.1     4      0 J0522-364              4200  [0]  [6.05] [CALIBRATE_BANDPASS#ON_SOURCE,CALIBRATE_PHASE#ON_SOURCE,CALIBRATE_WVR#ON_SOURCE]
              07:44:45.2 - 07:47:01.2     7      2 Ceres                  3800  [0]  [6.05] [CALIBRATE_AMPLI#ON_SOURCE,CALIBRATE_PHASE#ON_SOURCE,CALIBRATE_WVR#ON_SOURCE]
              07:52:42.0 - 07:53:47.6    10      3 J1037-295              1900  [0]  [6.05] [CALIBRATE_PHASE#ON_SOURCE,CALIBRATE_WVR#ON_SOURCE]
              07:56:23.5 - 08:02:11.3    12      5 TW Hya                 8514  [0]  [6.05] [OBSERVE_TARGET#ON_SOURCE]
              08:04:36.3 - 08:05:41.9    14      3 J1037-295              1900  [0]  [6.05] [CALIBRATE_PHASE#ON_SOURCE,CALIBRATE_WVR#ON_SOURCE]
              08:08:09.6 - 08:13:57.3    16      5 TW Hya                10360  [0]  [6.05] [OBSERVE_TARGET#ON_SOURCE]
              08:16:20.6 - 08:17:26.2    18      3 J1037-295              2100  [0]  [6.05] [CALIBRATE_PHASE#ON_SOURCE,CALIBRATE_WVR#ON_SOURCE]
              08:19:53.9 - 08:25:41.7    20      5 TW Hya                10321  [0]  [6.05] [OBSERVE_TARGET#ON_SOURCE]
              08:28:17.1 - 08:29:22.6    22      3 J1037-295              2100  [0]  [6.05] [CALIBRATE_PHASE#ON_SOURCE,CALIBRATE_WVR#ON_SOURCE]
              08:32:00.5 - 08:37:48.2    24      5 TW Hya                10324  [0]  [6.05] [OBSERVE_TARGET#ON_SOURCE]
              08:40:11.9 - 08:41:17.4    26      3 J1037-295              2100  [0]  [6.05] [CALIBRATE_PHASE#ON_SOURCE,CALIBRATE_WVR#ON_SOURCE]
              08:43:45.6 - 08:49:33.4    28      5 TW Hya                 9462  [0]  [6.05] [OBSERVE_TARGET#ON_SOURCE]
              08:51:57.1 - 08:53:02.6    30      3 J1037-295              1900  [0]  [6.05] [CALIBRATE_PHASE#ON_SOURCE,CALIBRATE_WVR#ON_SOURCE]
              08:58:12.0 - 09:00:28.1    33      6 3c279                  3402  [0]  [6.05] [CALIBRATE_BANDPASS#ON_SOURCE,CALIBRATE_PHASE#ON_SOURCE,CALIBRATE_WVR#ON_SOURCE]
              09:01:35.7 - 09:02:41.2    34      3 J1037-295              1900  [0]  [6.05] [CALIBRATE_PHASE#ON_SOURCE,CALIBRATE_WVR#ON_SOURCE]
              09:05:15.6 - 09:07:31.6    36      5 TW Hya                 4180  [0]  [6.05] [OBSERVE_TARGET#ON_SOURCE]
              09:09:59.1 - 09:11:04.7    38      3 J1037-295              2100  [0]  [6.05] [CALIBRATE_PHASE#ON_SOURCE,CALIBRATE_WVR#ON_SOURCE]
           (nRows = Total number of rows per scan)
```

listobs: lists the contents of measurement set

List of fields & spectral windows

```
Fields: 5
  ID   Code Name         RA               Decl           Epoch   SrcId      nRows
  0    none J0522-364    05:22:57.984648 -36.27.30.85128 J2000   0          4200
  2    none Ceres        06:10:15.950590 +23.22.06.90668 J2000   2          3800
  3    none J1037-295    10:37:16.079736 -29.34.02.81316 J2000   3          16000
  5    none TW Hya       11:01:51.796000 -34.42.17.36600 J2000   4          53161
  6    none 3c279        12:56:11.166576 -05.47.21.52464 J2000   5          3402
Spectral Windows:  (1 unique spectral windows and 1 unique polarization setups)
  SpwID  Name                        #Chans   Frame   Ch0(MHz)  ChanWid(kHz)  TotBW(kHz) CtrFreq(MHz) BBC Num  Corrs
  0      ALMA_RB_07#BB_2#SW-01#FULL_RES   384   TOPO  372533.086      610.352    234375.0 372649.9688       2  XX  YY
Sources: 5
  ID   Name          SpwId RestFreq(MHz)  SysVel(km/s)
  0    J0522-364     0     -              -
  1    Ceres         0     -              -
  2    J1037-295     0     -              -
  3    TW Hya        0     -              -
  4    3c279         0     -              -
```

Antenna names & positions

```
Antennas: 21:
  ID   Name  Station   Diam.    Long.         Lat.         Offset from array center (m)          ITRF Geocentric coordinates (m)
                                                           East         North     Elevation       x              y               z
  1    DA42  A050      12.0 m   -067.45.16.2  -22.53.29.3    43.0352    -744.9713   21.6702  2225079.880016 -5440041.377534 -2481724.598031
  2    DA44  A068      12.0 m   -067.45.20.6  -22.53.25.7   -82.4232    -631.7828   23.5810  2224981.097784 -5440131.250387 -2481621.066374
  3    DA45  A070      12.0 m   -067.45.11.9  -22.53.29.3   166.1833    -743.4934   19.8811  2225193.450167 -5439993.764157 -2481722.540534
  4    DA46  A067      12.0 m   -067.45.12.7  -22.53.27.2   142.4097    -678.7318   20.1280  2225181.070532 -5440026.290790 -2481662.975103
  5    DA48  A046      12.0 m   -067.45.17.0  -22.53.29.3    21.4267    -742.7987   21.6757  2225060.202580 -5440050.344436 -2481722.598651
  6    DA49  A029      12.0 m   -067.45.18.2  -22.53.25.8   -12.9134    -636.4552   22.1350  2225044.239583 -5440102.022535 -2481624.808405
  7    DA50  A045      12.0 m   -067.45.17.9  -22.53.30.1    -5.4183    -767.4398   22.6034  2225032.051652 -5440052.426015 -2481745.660003
  9    DV02  A077      12.0 m   -067.45.10.1  -22.53.25.9   217.6299    -637.5333   15.8376  2225255.259272 -5440008.987869 -2481623.352052
  11   DV05  A082      12.0 m   -067.45.08.3  -22.53.29.2   269.0433    -740.9521   15.7832  2225287.593766 -5439952.243679 -2481718.605314
  12   DV06  A037      12.0 m   -067.45.17.5  -22.53.28.8     6.7403    -727.3003   21.2086  2225048.729287 -5440061.085777 -2481708.139136
  14   DV08  A021      12.0 m   -067.45.17.2  -22.53.27.0    14.3196    -672.8108   21.3420  2225063.814715 -5440077.948261 -2481657.992572
  15   DV10  A071      12.0 m   -067.45.19.9  -22.53.23.5   -60.7887    -563.2541   23.3799  2225011.141945 -5440147.560932 -2481557.855663
  16   DV13  A072      12.0 m   -067.45.12.6  -22.53.24.0   147.1742    -580.5887   18.1825  2225199.254375 -5440058.161494 -2481571.803699
  17   DV15  A074      12.0 m   -067.45.12.1  -22.53.32.0   161.8159    -828.6196   18.7688  2225176.483514 -5439963.820451 -2481800.529842
  18   DV16  A069      12.0 m   -067.45.21.3  -22.53.30.2  -101.4797    -770.1047   23.2972  2224942.993176 -5440088.421459 -2481748.384855
  19   DV17  A138      12.0 m   -067.45.17.1  -22.53.34.4    19.1461    -901.2603   26.0137  2225036.269025 -5439997.853009 -2481870.267607
  20   DV18  A053      12.0 m   -067.45.17.3  -22.53.31.2    12.5939    -802.9941   21.5281  2225043.111690 -5440031.889497 -2481777.995870
  21   DV19  A008      12.0 m   -067.45.15.4  -22.53.26.8    67.5592    -667.6872   20.9574  2225113.709955 -5440059.310545 -2481653.122797
  22   DV20  A020      12.0 m   -067.45.17.8  -22.53.28.0    -2.9649    -703.4389   21.6629  2225043.419055 -5440073.737929 -2481686.333574
  24   DV22  A011      12.0 m   -067.45.14.4  -22.53.28.4    95.9131    -716.5005   21.0898  2225132.810230 -5440031.115405 -2481698.143589
  25   DV23  A007      12.0 m   -067.45.15.1  -22.53.27.3    74.0152    -681.2926   21.3231  2225117.809276 -5440052.280005 -2481665.799049
Task listobs complete. Start time: 2021-11-29 22:42:19.113889 End time: 2021-11-29 22:42:19.209607
##### End Task: listobs          #####
##########################################
##########################################
```

Getting started on the Allegro computers

1. Go to the analysis folder in the project directory

```
> cd
/allegro1/allegro/home/your_username/open_ALMA_DRT2023/analysis/your_username
```

2. Make two folders

```
> mkdir imaging
> mkdir analysis_tools
```

3. Copy data from the 'archive' folder to your own folder

```
> cp -r
../../archive/DRT2023/TW_hydra/sis14_twhya_calibrated_flagged.ms.contsub
imaging/.
> cp -r ../../archive/DRT2023/TW_hydra/twhya_n2hp.image analysis_tools/.
> cp -r ../../archive/DRT2023/TW_hydra/sis14_twhya_cont.image analysis_tools/.
> cp -r ../../archive/DRT2023/TW_hydra/*.fits analysis_tools/.
```

4. Copy scripts from the 'scripts' folder to your own folder

```
> cp ../../scripts/Imaging*.py imaging/.
> cp ../../scripts/analysis*.py analysis_tools/.
```

5. Go to the `imaging` folder and open CASA

```
> cd imaging
> nice +10 env -u PYTHONPATH -u LD_LIBRARY_PATH casapy-660
```