

The CASA Software

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CASA is...

CASA = Common Astronomy Software Applications

- *CASA is a set of C++ application libraries for the data reduction and analysis of radio astronomical data*
- *applications run through the IPython interface to Python*
- *developed for ALMA and EVLA projects*
- *...but also for data from other radio, millimeter, and sub-mm telescopes*

CASA design and implementation

Overall architecture:

- A data structure
Tables: Images, Caltables, and the Measurement Set
- A set of data import/export facilities
the so-called fillers: ASDM → MS, FITS → MS, UVFITS → MS, PdBI → MS, etc.
- A set of low-level tools for data access, display, and editing ,
tools to load/write data into/from casacore datatypes, matplotlib for basic x/y plotting
Qt-based table browser

CASA design and implementation

- A set of high-level tools for science analysis built around *the Measurement Equation* (Hamaker 1996)
- A programmable command line interface with scripting
Python (augmented by IPython) gives a MATLAB-like interactive language
- Documentation
inline documentation using doxygen + an extensive cookbook (500 pages) + user reference manual

How does CASA look ?

**Installation - CASA comes as a tgz-file for Linux or a
dmg-file for Mac OS-X**

See "Obtaining CASA" link on <http://casa.nrao.edu/>
Download latest version at
http://casa.nrao.edu/casa_obtaining.shtml

Linux:

Unpack tgz file in a location of your choice.
cd into the created casapy directory.
export PATH=\$PWD:\$PATH

Mac OS-X:

Open the CASA disk image file
Double-click the CASA application to run it for the first time.

Task and Tools

- Task: high (user) level functionality
 - call from Python as functions
 - standard tasking interface
 - parameter manipulation using `inp`, `default`, `saveinputs`, `tget`
 - arguments are parameters
 - documentation: Cookbook
- Toolkit: full functionality represented
 - tools are functions and underlying tasks
 - documentation: Reference Manual

The CASA user interface

Starting up CASA... preliminary operations (only for ARC cluster!)

```
ssh scheduler -l username -X
```

Username = almauserN

Password = almaNpasswd

N = 1→10 i.e.

```
>ssh scheduler -l almauser3 -X
```

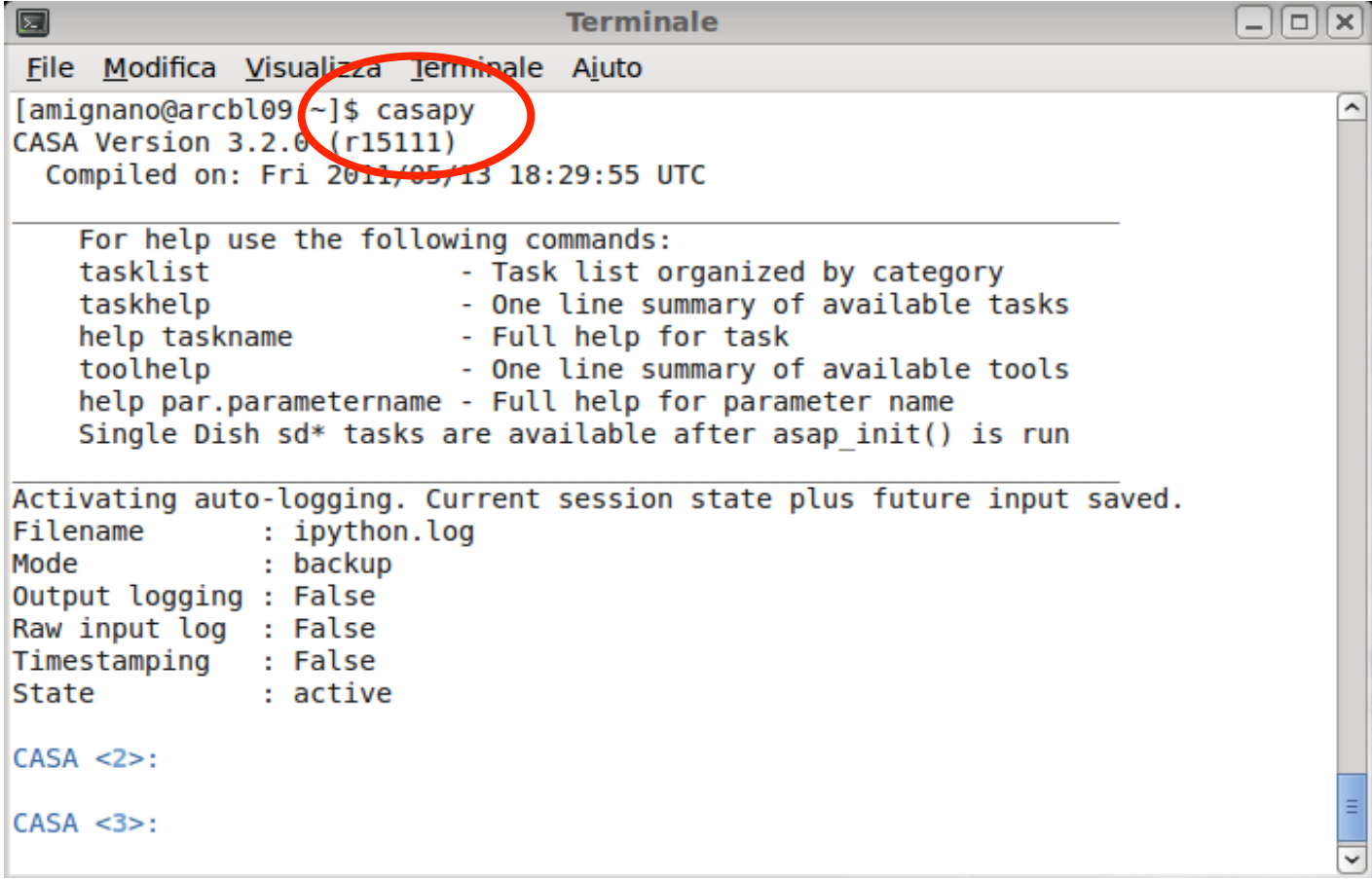
```
>Enter passwd: alma3passwd
```

```
cd FIRSTLOOK_DATA/ NGC3256_SV/ ANTENNAE_SV/
```

```
casapy-setup (tab is your friend!!)
```


The CASA user interface

Starting up CASA...



```
Terminale
File Modifica Visualizza Terminale Ajuto
[amignano@arcbl09 ~]$ casapy
CASA Version 3.2.0 (r15111)
  Compiled on: Fri 2011/05/13 18:29:55 UTC

-----
For help use the following commands:
tasklist           - Task list organized by category
taskhelp           - One line summary of available tasks
help taskname      - Full help for task
toolhelp           - One line summary of available tools
help par.parametername - Full help for parameter name
Single Dish sd* tasks are available after asap_init() is run

-----
Activating auto-logging. Current session state plus future input saved.
Filename          : ipython.log
Mode               : backup
Output logging    : False
Raw input log     : False
Timestamping      : False
State              : active

CASA <2>:
CASA <3>:
```

The CASA user interface

```
CASA <3 : tasklist
-----> tasklist()
Available tasks, organized by category (experimental tasks in parens ()
  deprecated tasks in curly brackets {}).
  Single Dish sd* tasks are available after asap_init() is run.
```

Import/export	Information	Editing	Manipulation
-----	-----	-----	-----
exportfits	imhead	fixvis	concat
exportuvfits	imstat	flagautocorr	conjugatevis
importaipscaltable	imval	flagcmd	cvel
importasdm	listcal	flagdata	hanningsmooth
importevla	listhistory	flagmanager	imhead
importfits	listobs	msview	msmoments
importfitsidi	listvis	plotms	plotms
importuvfits	plotms	plotxy	plotxy
importvla	plotxy	(flagdata2)	split
(exportasdm)	vishead		testconcat
(importevla2)	visstat		vishead
(importgmt)			(uvcontsub2)
{importoldasdm}			
Calibration	Modeling	Imaging	Analysis
-----	-----	-----	-----
accum	setjy	clean	imcollapse
applycal	uvcontsub	deconvolve	imcontsub
bandpass	uvmodelfit	feather	imfit
blcal	uvsub	ft	imhead
calstat	(uvcontsub2)	imcontsub	immath
clearcal		(autoclean)	immoments
fixvis		(boxit)	imregrid
fluxscale		(csvclean)	imsmooth
fringecal		{mosaic}	imstat
ft		{widefield}	imtrans
gaincal			imval
gencal			listvis
listcal			slsearch
plotants			splattotable
plotcal			(specfit)
polcal			
setjy			
smoothcal			
uvmodelfit			
uvsub			

The Logger

The CASA user interface

The screenshot shows a window titled "Log Messages (paramay.ira.inaf.it:/Locale/CASA/tutorials/Bonn09-tutorial/Jupiter/flagdemo/casapy.log)". The window has a menu bar with "File", "Edit", and "View". Below the menu bar is a toolbar with icons for print, save, copy, and search. A "Search Message:" text box and a "Filter: Time" dropdown menu are also present. The main area is a table with columns "Time", "Origin", and "Message". The log entries show the execution of the "importuvfits" task, including file conversion, reading visibility groups, and assuming standard epochs for various planets. The task ends with "End Task: importuvfits".

Time	Origin	Message
2009-11-12 10:10...	importuvfi...	importuvfi...
2009-11-12 10:10...	importuvfi...	#####
2009-11-12 10:10...	importuvfi...	##### Begin Task: importuvfits #####
2009-11-12 10:10...	importuvfi...	importuvfi...
2009-11-12 10:10...	importuvfi...	importuvfi...
2009-11-12 10:10...	importuvfi...	Converting FITS file 'planets_6cm.fits' to MeasurementSet 'jupiter6cm_demo.ms'
2009-11-12 10:10...	importuvfi...	Using tile shape [4, 1, 4096] for VLA with obstype=0
2009-11-12 10:10...	importuvfi...	Reading and writing 1010712 visibility groups
2009-11-12 10:10...	importuvfi...	Found binary table of type AIPS AN following data
2009-11-12 10:10...	importuvfi...	Found binary table of type AIPS NX following data
2009-11-12 10:10...	importuvfi...	Skipping table, duplicate or unrecognized type: AIPS NX
2009-11-12 10:10...	importuvfi...	Found binary table of type AIPS SU following data
2009-11-12 10:10...	importuvfi...	Assuming standard epoch for VENUS. Be aware that this may not be correct.
2009-11-12 10:10...	importuvfi...	Assuming standard epoch for MARS. Be aware that this may not be correct.
2009-11-12 10:10...	importuvfi...	Assuming standard epoch for NEPTUNE. Be aware that this may not be correct.
2009-11-12 10:10...	importuvfi...	Assuming standard epoch for URANUS. Be aware that this may not be correct.
2009-11-12 10:10...	importuvfi...	Assuming standard epoch for JUPITER. Be aware that this may not be correct.
2009-11-12 10:10...	importuvfi...	Found binary table of type AIPS FQ following data
2009-11-12 10:10...	importuvfi...	Found binary table of type AIPS CL following data
2009-11-12 10:10...	importuvfi...	Skipping table, duplicate or unrecognized type: AIPS CL
2009-11-12 10:11...	importuvfi...	Found binary table of type AIPS TY following data
2009-11-12 10:11...	importuvfi...	Skipping table, duplicate or unrecognized type: AIPS TY
2009-11-12 10:11...	importuvfi...	importuvfi...
2009-11-12 10:11...	importuvfi...	##### End Task: importuvfits #####
2009-11-12 10:11...	importuvfi...	#####

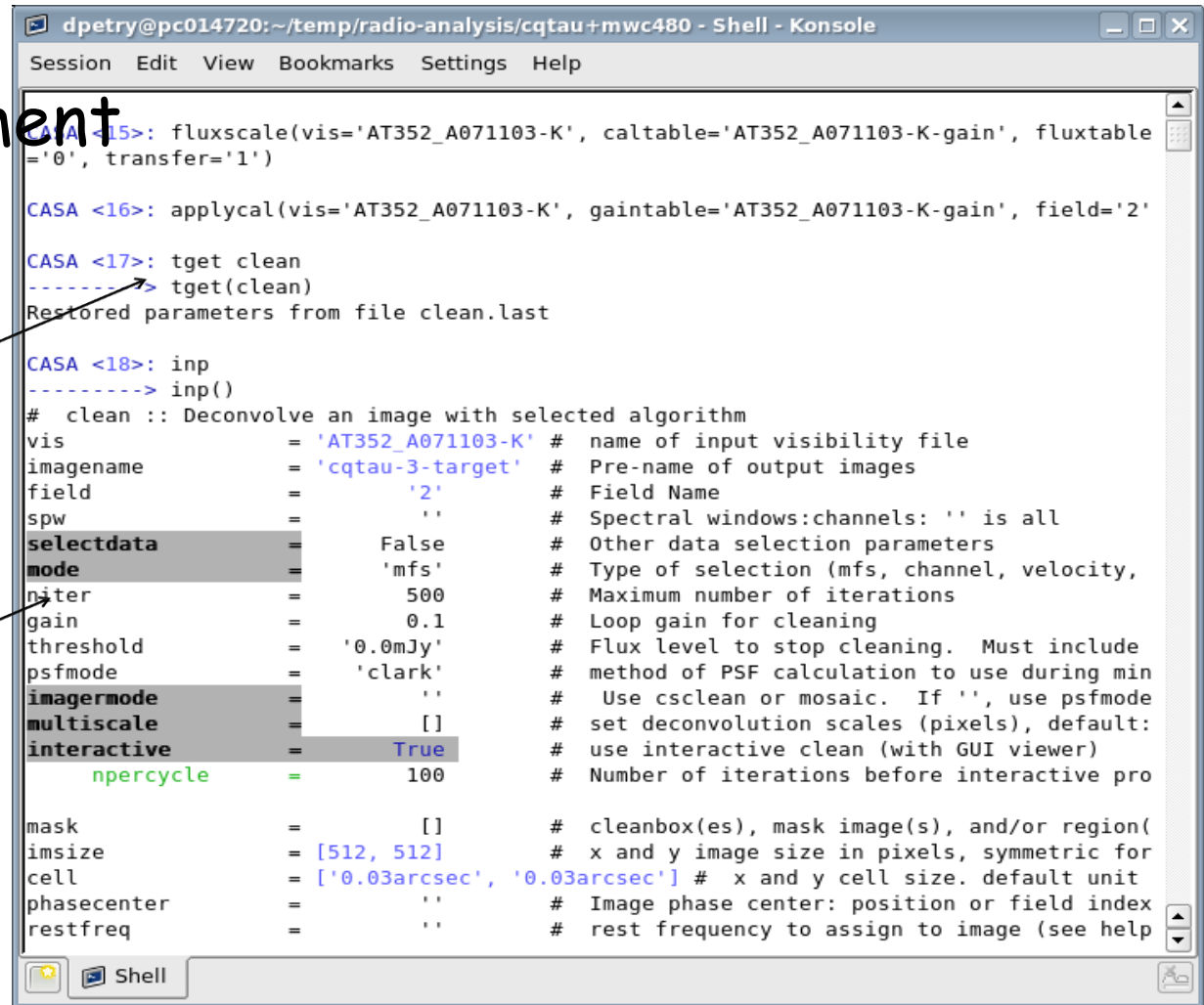
At the bottom of the window, there is an "Insert Message:" text box and a toolbar with icons for add, edit, and refresh, along with a "Lock scroll" checkbox.

The CASA user interface

enter commands in a
MATLAB-like environment

recall previous settings

list present settings
for current task
(includes parameter
verification)



```
dpetry@pc014720:~/temp/radio-analysis/cqtau+mwc480 - Shell - Konsole
Session Edit View Bookmarks Settings Help

CASA <15>: fluxscale(vis='AT352_A071103-K', caltable='AT352_A071103-K-gain', fluxtable
='0', transfer='1')

CASA <16>: applycal(vis='AT352_A071103-K', gaintable='AT352_A071103-K-gain', field='2'

CASA <17>: tget clean
-----> tget(clean)
Restored parameters from file clean.last

CASA <18>: inp
-----> inp()

# clean :: Deconvolve an image with selected algorithm
vis                = 'AT352_A071103-K' # name of input visibility file
imagename          = 'cqtau-3-target'  # Pre-name of output images
field              = '2'               # Field Name
spw                = ''                # Spectral windows:channels: '' is all
selectdata         = False             # Other data selection parameters
mode               = 'mfs'             # Type of selection (mfs, channel, velocity,
niter              = 500               # Maximum number of iterations
gain               = 0.1               # Loop gain for cleaning
threshold          = '0.0mJy'         # Flux level to stop cleaning. Must include
psfmode           = 'clark'           # method of PSF calculation to use during min
imagermode        = ''                 # Use csclean or mosaic. If '', use psfmode
multiscale         = []                # set deconvolution scales (pixels), default:
interactive        = True               # use interactive clean (with GUI viewer)
npercycle          = 100               # Number of iterations before interactive pro

mask               = []                # cleanbox(es), mask image(s), and/or region(
imsize             = [512, 512]        # x and y image size in pixels, symmetric for
cell               = ['0.03arcsec', '0.03arcsec'] # x and y cell size. default unit
phasecenter        = ''                # Image phase center: position or field index
restfreq           = ''                # rest frequency to assign to image (see help
```

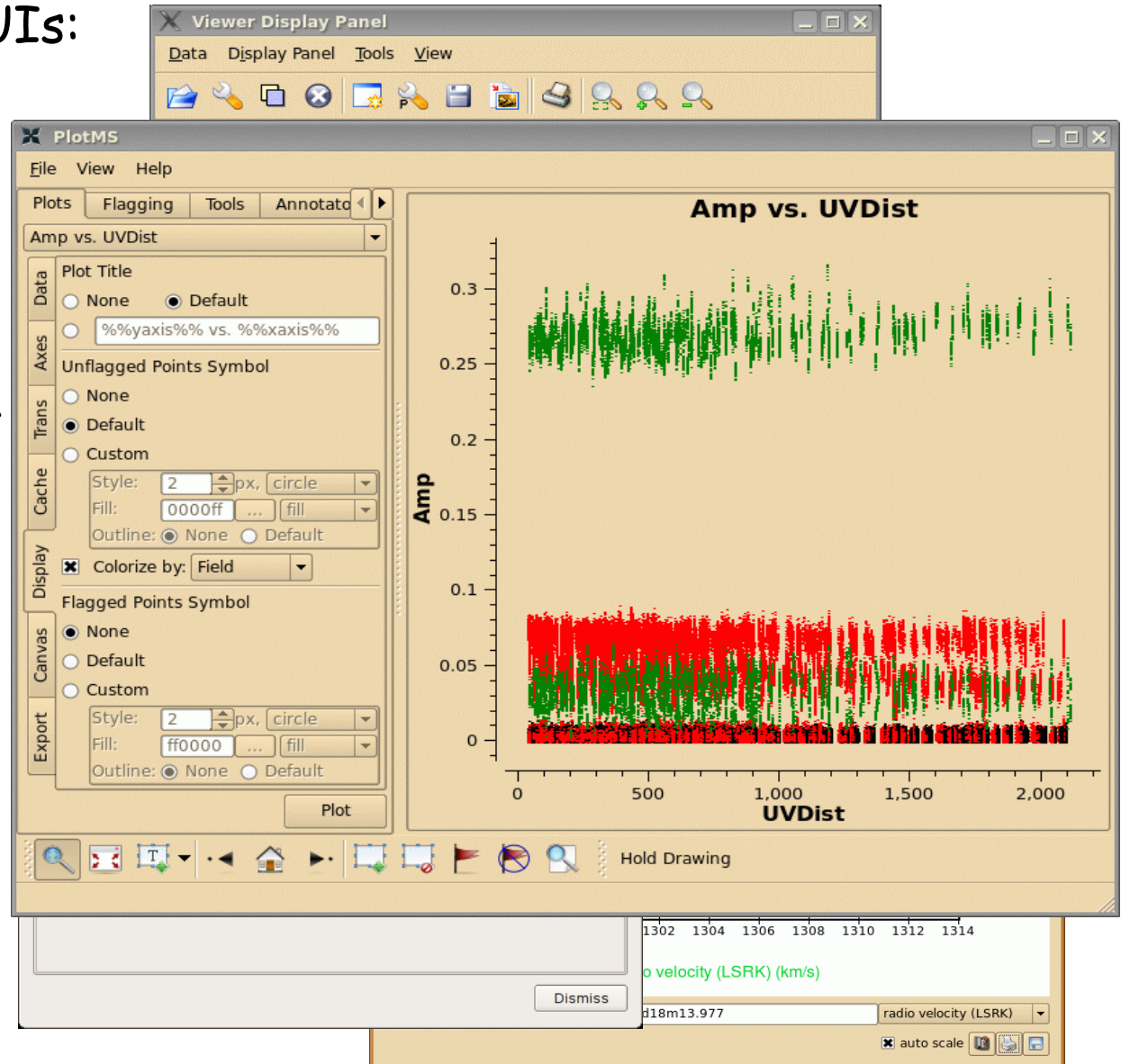
The CASA user interface

Where needed, tools have GUIs:

Plotxy, plotcal, browstable,
viewer, plotms

The *viewer* is a powerful
multi-function tool for data
selection
and visualization.

Plotms is going to replace
plotxy, but still in beta
(advanced) version.



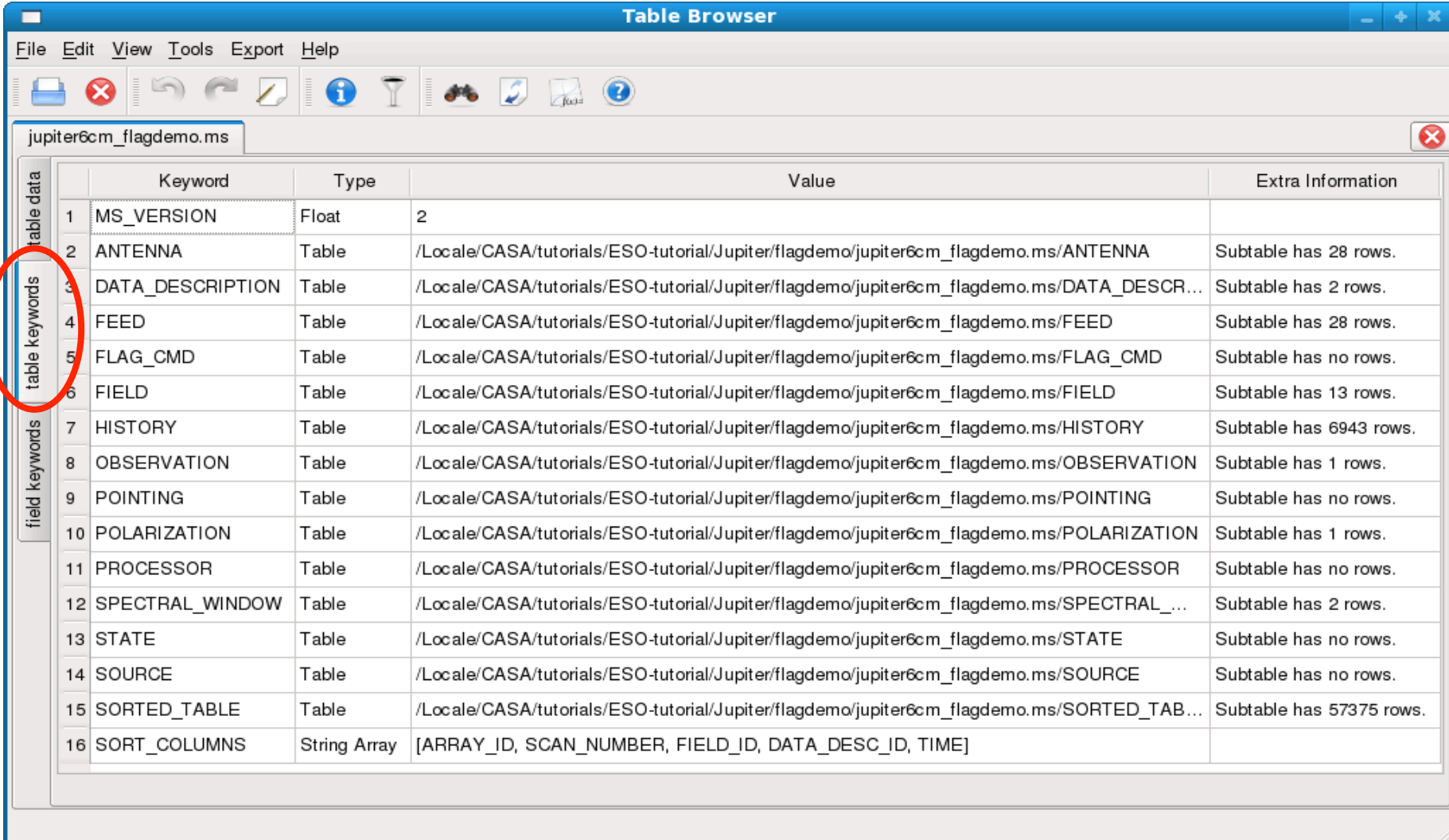
The CASA user interface

browsetable: allows you to display any CASA table, e.g. Measurement

The screenshot shows the 'Table Browser' window in CASA. The window title is 'Table Browser'. The menu bar includes 'File', 'Edit', 'View', 'Tools', 'Export', and 'Help'. The toolbar contains various icons for file operations and viewing. The main area displays a table with columns: UVW, FLAG, FLAG_CATEGORY, WEIGHT, SIGMA, ANTENNA1, ANTENNA2, and AR. The table has 12 rows, with the first row highlighted. A red circle highlights the 'table data' button in the left sidebar. The status bar at the bottom shows 'PAGE NAVIGATION' with buttons for 'First', '<<', '[1 / 2022]', '>>', and 'Last'. A text box shows '1' and a 'Go' button. The status bar also indicates 'Loading 1000 rows.'.

	UVW	FLAG	FLAG_CATEGORY	WEIGHT	SIGMA	ANTENNA1	ANTENNA2	AR
0	[-68.7658, -4...	[4, 1] Boolean	[0, 0, 0] Boolean	[0, 0, 0.333333, 0]	[0, 0, 1.73205, 0]	0	9	0
1	[-68.7658, -4...	[4, 1] Boolean	[0, 0, 0] Boolean	[0.333333, 0, 0.333333, 0]	[1.73205, 0, 1.73205, 0]	0	9	0
2	[-218.848, 42...	[4, 1] Boolean	[0, 0, 0] Boolean	[0, 0, 0, 0]	[0, 0, 0, 0]	7	9	0
3	[-218.848, 42...	[4, 1] Boolean	[0, 0, 0] Boolean	[0.333333, 0, 0.333333, 0]	[1.73205, 0, 1.73205, 0]	7	9	0
4	[-16.7846, 12...	[4, 1] Boolean	[0, 0, 0] Boolean	[0, 0, 0, 0]	[0, 0, 0, 0]	4	9	0
5	[-16.7846, 12...	[4, 1] Boolean	[0, 0, 0] Boolean	[0, 0, 0.333333, 0]	[0, 0, 1.73205, 0]	4	9	0
6	[150.083, -86...	[4, 1] Boolean	[0, 0, 0] Boolean	[0, 0, 0, 0]	[0, 0, 0, 0]	0	7	0
7	[150.083, -86...	[4, 1] Boolean	[0, 0, 0] Boolean	[0.333333, 0.333333, 0.333333, ...]	[1.73205, 1.73205, 1.73...	0	7	0
8	[-51.9812, -5...	[4, 1] Boolean	[0, 0, 0] Boolean	[0, 0, 0, 0]	[0, 0, 0, 0]	0	4	0
9	[-51.9812, -5...	[4, 1] Boolean	[0, 0, 0] Boolean	[0, 0.333333, 0, 0.333333]	[0, 1.73205, 0, 1.73205]	0	4	0
10	[202.064, -30...	[4, 1] Boolean	[0, 0, 0] Boolean	[0, 0, 0, 0]	[0, 0, 0, 0]	4	7	0
11	[202.064, -30...	[4, 1] Boolean	[0, 0, 0] Boolean	[0, 0, 0.333333, 0.333333]	[0, 0, 1.73205, 1.73205]	4	7	0

The CASA user interface



	Keyword	Type	Value	Extra Information
1	MS_VERSION	Float	2	
2	ANTENNA	Table	/Locale/CASA/tutorials/ESO-tutorial/Jupiter/flagdemo/jupiter6cm_flagdemo.ms/ANTENNA	Subtable has 28 rows.
3	DATA_DESCRIPTION	Table	/Locale/CASA/tutorials/ESO-tutorial/Jupiter/flagdemo/jupiter6cm_flagdemo.ms/DATA_DESCR...	Subtable has 2 rows.
4	FEED	Table	/Locale/CASA/tutorials/ESO-tutorial/Jupiter/flagdemo/jupiter6cm_flagdemo.ms/FEED	Subtable has 28 rows.
5	FLAG_CMD	Table	/Locale/CASA/tutorials/ESO-tutorial/Jupiter/flagdemo/jupiter6cm_flagdemo.ms/FLAG_CMD	Subtable has no rows.
6	FIELD	Table	/Locale/CASA/tutorials/ESO-tutorial/Jupiter/flagdemo/jupiter6cm_flagdemo.ms/FIELD	Subtable has 13 rows.
7	HISTORY	Table	/Locale/CASA/tutorials/ESO-tutorial/Jupiter/flagdemo/jupiter6cm_flagdemo.ms/HISTORY	Subtable has 6943 rows.
8	OBSERVATION	Table	/Locale/CASA/tutorials/ESO-tutorial/Jupiter/flagdemo/jupiter6cm_flagdemo.ms/OBSERVATION	Subtable has 1 rows.
9	POINTING	Table	/Locale/CASA/tutorials/ESO-tutorial/Jupiter/flagdemo/jupiter6cm_flagdemo.ms/POINTING	Subtable has no rows.
10	POLARIZATION	Table	/Locale/CASA/tutorials/ESO-tutorial/Jupiter/flagdemo/jupiter6cm_flagdemo.ms/POLARIZATION	Subtable has 1 rows.
11	PROCESSOR	Table	/Locale/CASA/tutorials/ESO-tutorial/Jupiter/flagdemo/jupiter6cm_flagdemo.ms/PROCESSOR	Subtable has no rows.
12	SPECTRAL_WINDOW	Table	/Locale/CASA/tutorials/ESO-tutorial/Jupiter/flagdemo/jupiter6cm_flagdemo.ms/SPECTRAL_...	Subtable has 2 rows.
13	STATE	Table	/Locale/CASA/tutorials/ESO-tutorial/Jupiter/flagdemo/jupiter6cm_flagdemo.ms/STATE	Subtable has no rows.
14	SOURCE	Table	/Locale/CASA/tutorials/ESO-tutorial/Jupiter/flagdemo/jupiter6cm_flagdemo.ms/SOURCE	Subtable has no rows.
15	SORTED_TABLE	Table	/Locale/CASA/tutorials/ESO-tutorial/Jupiter/flagdemo/jupiter6cm_flagdemo.ms/SORTED_TAB...	Subtable has 57375 rows.
16	SORT_COLUMNS	String Array	[ARRAY_ID, SCAN_NUMBER, FIELD_ID, DATA_DESC_ID, TIME]	

Data in CASA

- Data in CASA are stored in tables
 - also tables for images and calibration tables
- Visibility data are stored in Measurement Set (MS) table
- the MS is a directory on the disk
 - MAIN table containing the visibility data
 - sub-tables (=sub-directories) containing auxiliary information
 - e.g. FIELD, SPECTRAL WIN., ANTENNA, etc.

Data in CASA

```
Terminal
File Edit View Terminal Tabs Help
paramay:/Locale/CASA/tutorials/Bonn09-tutorial/Jupiter/flagdemo> ls jupiter6cm_demo.ms
ANTENNA          OBSERVATION    SPECTRAL_WINDOW  table.f2_TSM1    table.f6          table.info
DATA_DESCRIPTION POINTING       STATE             table.f3         table.f6_TSM0    table.lock
FEED             POLARIZATION  table.dat         table.f3_TSM1    table.f7
FIELD           PROCESSOR     table.f0         table.f4         table.f7_TSM1
FLAG_CMD        SORTED_TABLE  table.f1         table.f5         table.f8
HISTORY         SOURCE        table.f2         table.f5_TSM1    table.f8_TSM1
paramay:/Locale/CASA/tutorials/Bonn09-tutorial/Jupiter/flagdemo>
```

```
Terminal
File Edit View Terminal Tabs Help
paramay:/Locale/CASA/tutorials/Bonn09-tutorial/Jupiter/flagdemo> ls jupiter6cm_demo.ms/FIELD
table.dat table.f0 table.f0i table.info table.lock
paramay:/Locale/CASA/tutorials/Bonn09-tutorial/Jupiter/flagdemo>
```

Data in CASA

The Measurement Set ...

- developed by Cornwell, Kemball, & Wieringa between 1996 and 2000
- designed to store both interferometry (multi-dish) and single-dish data
- supports (in principle) any setup of radio telescopes
- supports description and processing of the data via the Measurement Equation

Data in CASA

What's in the Measurement Set?

MAIN	Model, e.g.:	Corrected data	Flags
Original visibility data	<i>FT of image made from MS</i> <i>FT of supplied model image</i> <i>FT of calibrator flux density</i>	<i>Copy of visibilities with calibration tables applied</i> (Used in imaging but not calibration)	(Edits are stored here first; backup tables can be made and used to modify)

There are scratch columns

CASA in practice

The Measurement Equation (Hamaker, Bregman & Sault 1996)

- decompose into individual calibration components,

where:

$$\vec{V}_{ij}^{obs} = \vec{B}_{ij} \vec{G}_{ij} \vec{D}_{ij} \vec{P}_{ij} \vec{T}_{ij} \vec{F}_{ij} \vec{V}_{ij}^{ideal}$$

B = Bandpass, G = gain, D = D-Term (pol. leakage),
T = Tropospheric effects, F = Faraday rotation

- linearise and solve by χ^2 minimization

Data Selection

- Standard MS selection syntax
 - e.g for task gaincal

```
CASA <24>: inp gaincal
-----> inp(gaincal)
# gaincal :: Determine temporal gains from calibrator observations
vis                = 'jupiter6cm.demo.ms/' # Name of input visibility file
caltable           = 'jupiter.gcal'        # Name of output gain calibration table
field              = '0137+331,1331+305'   # Select field using field id(s) or field name(s)
spw                = '0,1'                # Select spectral window/channels
selectdata       = True                  # Other data selection parameters
  timerange        = ''                    # Select data based on time range
  uvrange          = ''                    # Select data within uvrange (default units meters)
  antenna          = ''                    # Select data based on antenna/baseline
  scan             = ''                    # Scan number range
  msselect         = ''                    # Optional complex data selection (ignore for now)

solint             = 'inf'                 # Solution interval: egs. 'inf', '60s' (see help)
combine           = ''                     # Data axes which to combine for solve (scan, spw,
# and/or field)
```

- Field, spw common standard selection
- Expandable selectdata with other selection criteria
- Check you parameter by the “inp”

Data Selection

- field - string with source name or field ID
 - can use "*" as wildcard, first checks for name, then ID
 - e.g.:
 - field="1331+305";
 - field="3C286, 3C84";
 - field="0"
- spw - string with spectral window ID + channels
 - use ":" as separator of spw from channelization
 - use "~" as separator for ranges ("start~stop")
 - e.g.:
 - spw="0~2" , spectral windows 0,1,2
 - spw="1:10~30" , spectral window 1, channel 10-30 inclusive
 - spw="0~2:5~54^5" , spw 0,1,2 channels 5-54 in step of 5

Data Selection

- antenna - string with antenna name or ID
 - first check for name, then ID (VLA name 1-27, ID 0-26)
 - example:

antenna="1~5,11"; → from antenna 1 to 5 and antenna 11

antenna="VA06"; → all baseline with VA06 antenna

antenna="VA06&&" → autocorrelation

antenna="!VA06" → all baselines, except the ones with VA06

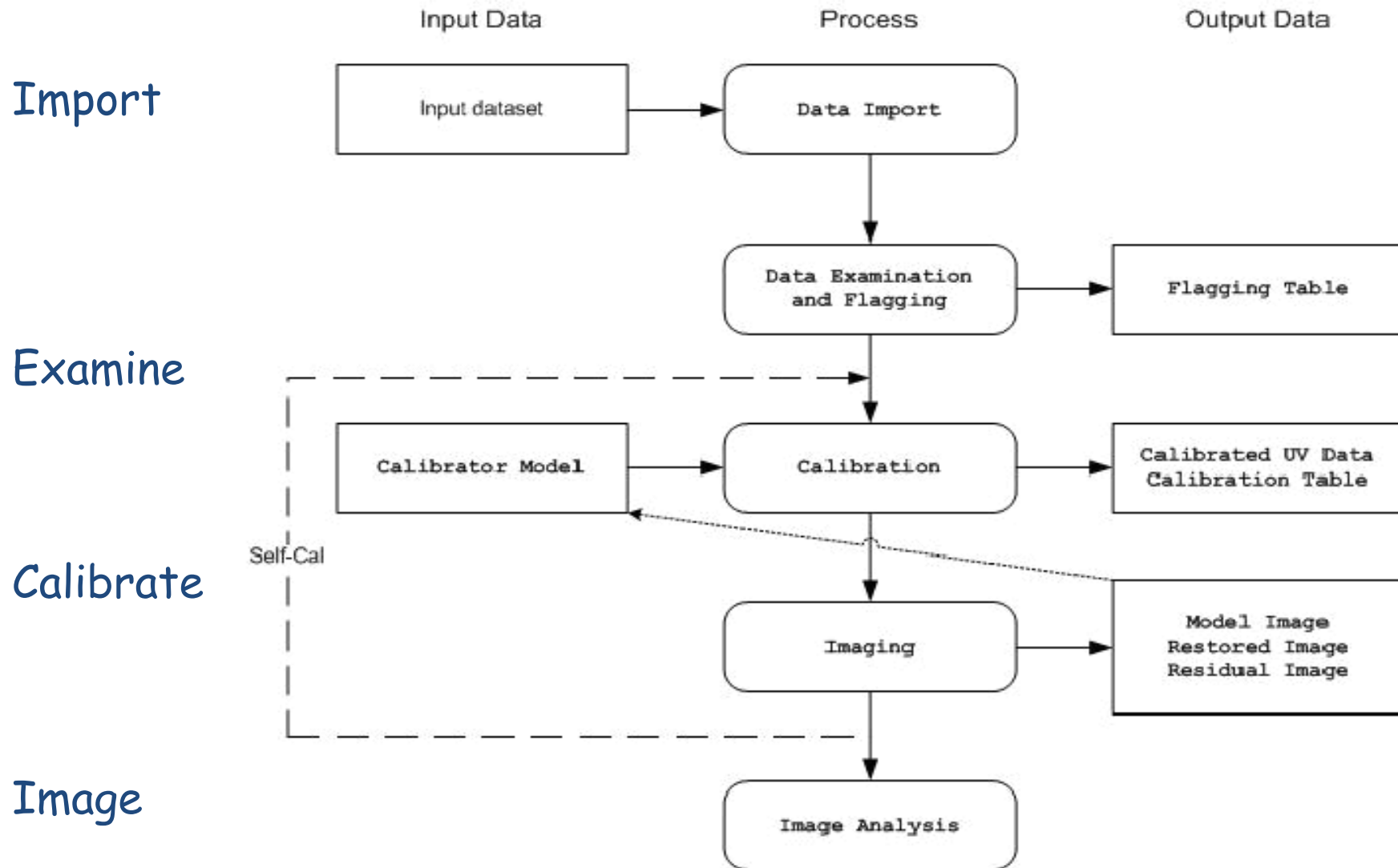
- Timerange - string with date/time range
 - specify "T0~T1", "T0+dT", ">T0"
 - example:

timerange="22:40:00~03:30:00"

timerange="23:41:00+01:00:00"

timerange=">23:41:00"

Processing Philosophy

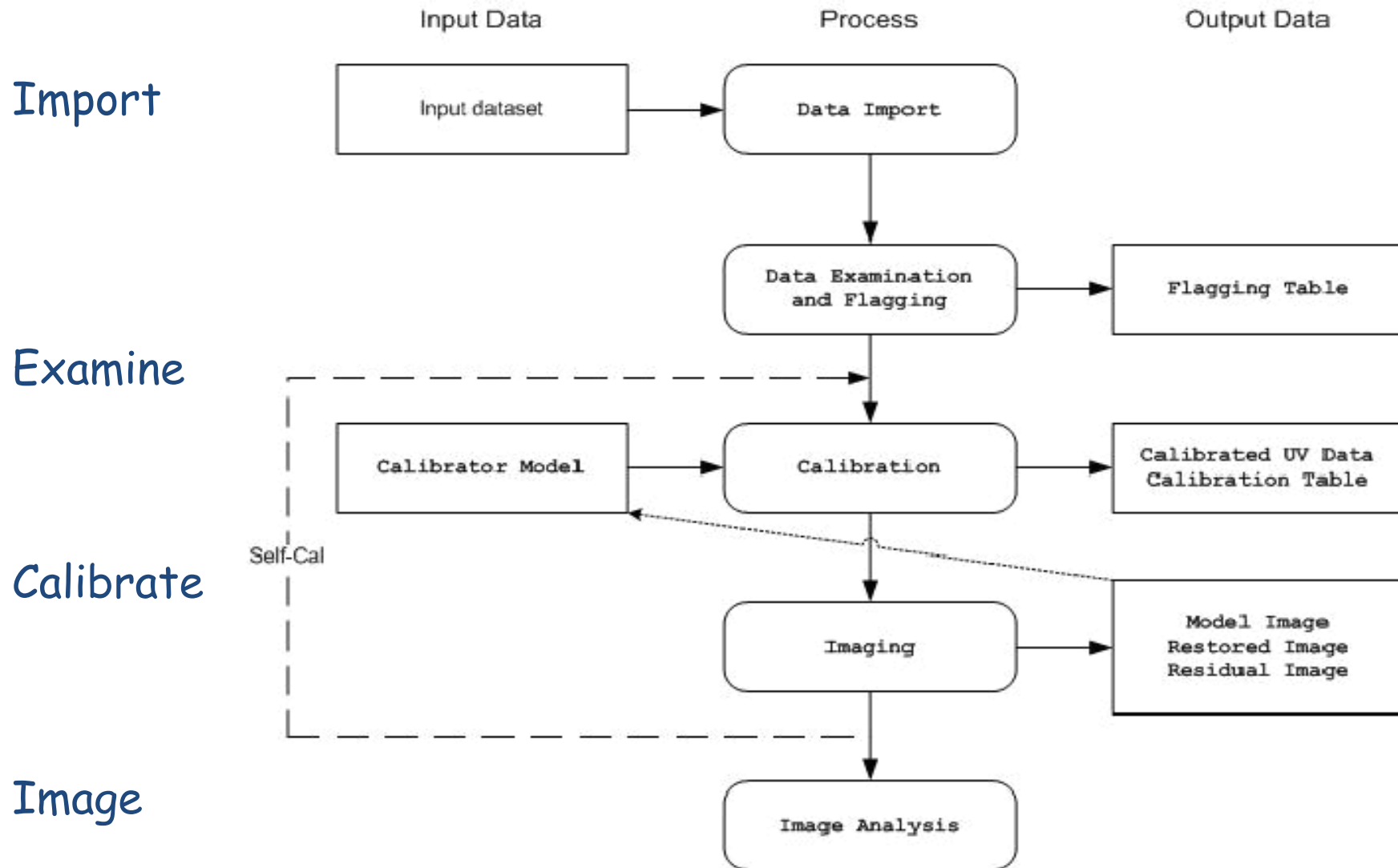


Processing Philosophy

Import Data

- task importuvfits
 - UVFITS data (e.g. from AIPS)
- task importvla
 - VLA "export" format (e.g. from archive)
- task **importasdm**
 - **ALMA data format** (also EVLA eventually)

Processing Philosophy



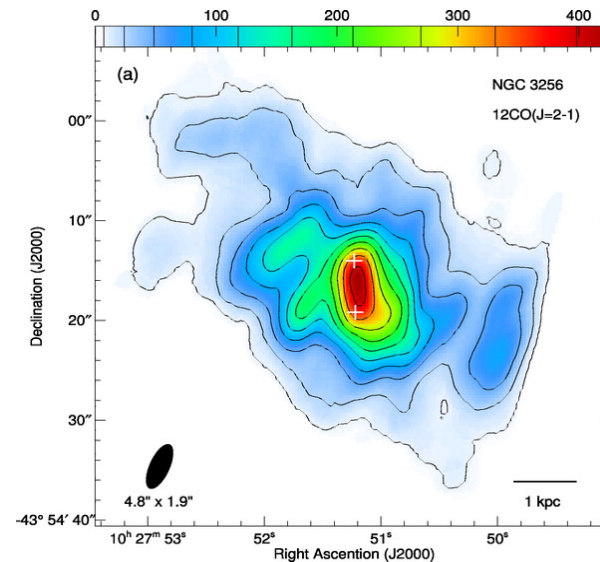
The Case of NGC3256

ALMA Science Verification Data (April, 16-17 2011)

- CO (1-0) Band 3
- spectral resolution 15.625 MHz (40 kms⁻¹)
- Angular resolution 6.5" (8 antennas)

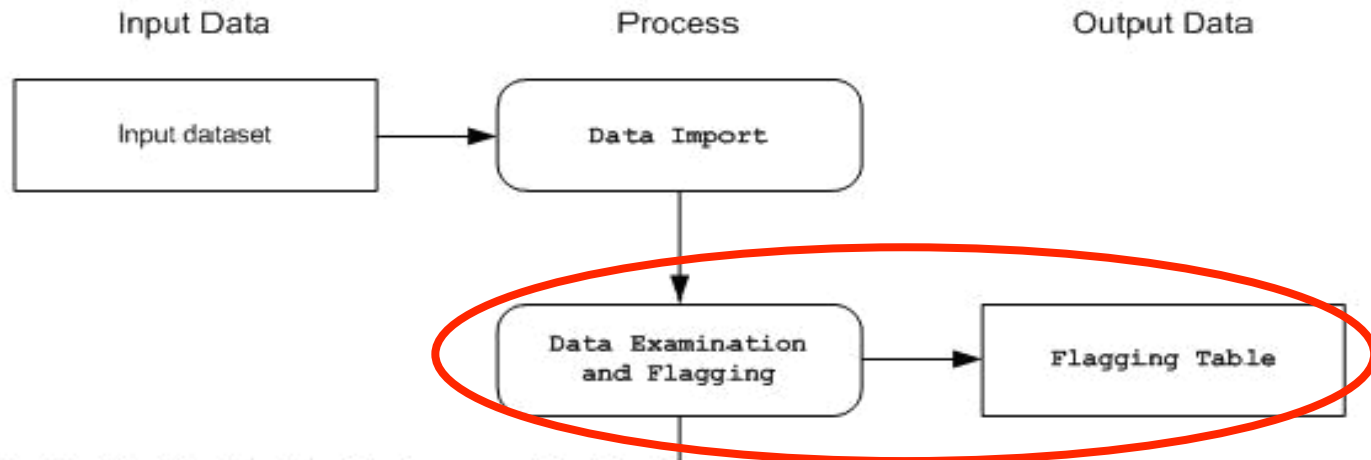


HST image of NGC3256 (credit: NASA, ESA, the Hubble Heritage Team (STScI/AURA)-ESA/Hubble Collaboration and A. Evans)

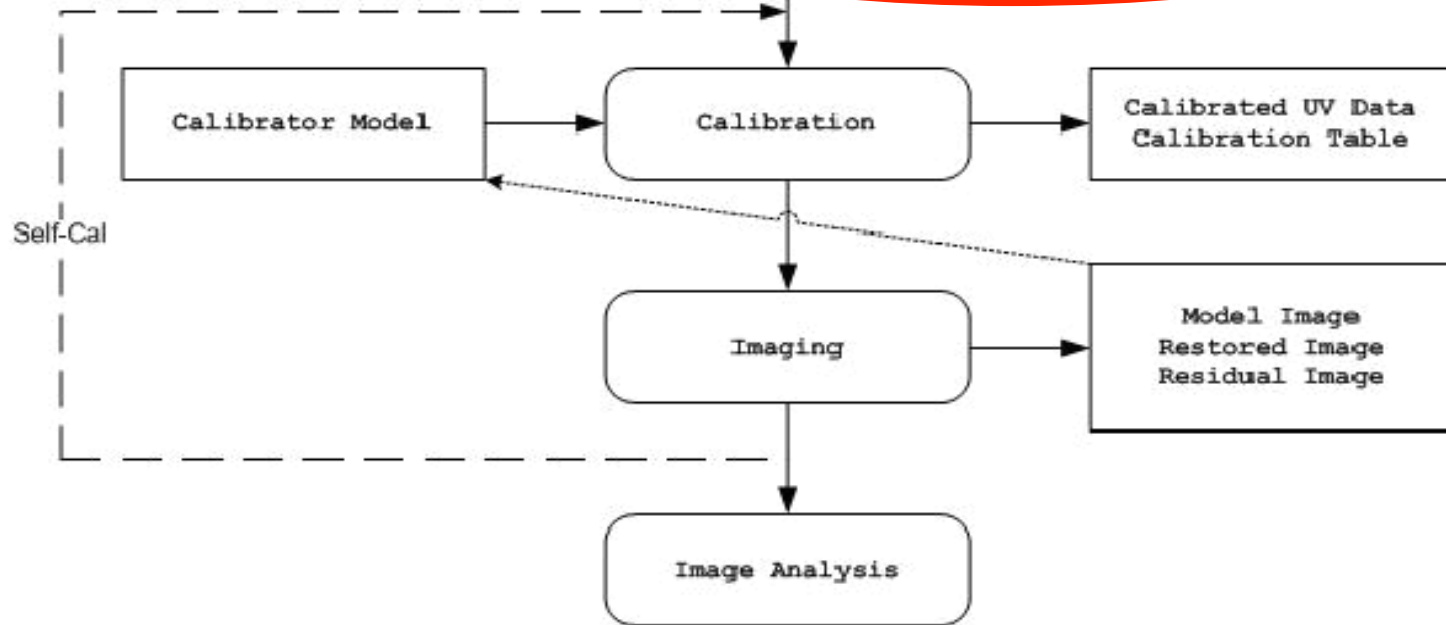


SMA map of CO (2-1) emission in the center of NGC 3256 (Sakamoto, Ho & Peck, 2006)

Import



Examine



Calibrate

Image

Data Examination and Flagging

Log Messages (arcbl11.ira.inaf.it:arcfs0/homesarc/amignano/test_scuola/calibrated/NGC3256_Band3_CalibratedData/casapy.log)

File Edit View

Search Message: Filter: Time

Time	Priority	Origin	Message
2011-06-15 15:33:52	INFO	listobs:..	04:06:02.3 - 04:06:26.4 131 2 NGC3256 720 6.05 [0, 1, 2, 3]
2011-06-15 15:33:52	INFO	listobs:..	04:06:39.2 - 04:07:03.4 131 2 NGC3256 720 6.05 [0, 1, 2, 3]
2011-06-15 15:33:52	INFO	listobs:..	04:07:16.2 - 04:07:40.4 131 2 NGC3256 720 6.05 [0, 1, 2, 3]
2011-06-15 15:33:52	INFO	listobs:..	04:08:05.9 - 04:08:11.9 132 0 1037-295 288 6.05 [0, 1, 2, 3]
2011-06-15 15:33:52	INFO	listobs:..	04:08:24.7 - 04:08:30.7 132 0 1037-295 288 6.05 [0, 1, 2, 3]
2011-06-15 15:33:52	INFO	listobs:..	04:08:43.5 - 04:08:49.5 132 0 1037-295 288 6.05 [0, 1, 2, 3]
2011-06-15 15:33:52	INFO	listobs:..	(nVis = Total number of time/baseline visibilities per scan)
2011-06-15 15:33:52	INFO	listobs:..	Fields: 3
2011-06-15 15:33:52	INFO	listobs:..	ID Code Name RA Decl Epoch SrcId nVis
2011-06-15 15:33:52	INFO	listobs:..	0 none 1037-295 10:37:16.0790 -29.34.02.8130 J2000 0 61440
2011-06-15 15:33:52	INFO	listobs:..	1 none Titan 12:51:03.6909 -02.30.58.3282 J2000 1 25344
2011-06-15 15:33:52	INFO	listobs:..	2 none NGC3256 10:27:51.6000 -43.54.18.0000 J2000 2 239616
2011-06-15 15:33:52	INFO	listobs:..	(nVis = Total number of time/baseline visibilities per field)
2011-06-15 15:33:52	INFO	listobs:..	Spectral Windows: (4 unique spectral windows and 1 unique polarization setups)
2011-06-15 15:33:52	INFO	listobs:..	SpwID #Chans Frame Ch1 (MHz) ChanWid (kHz) TotBW (kHz) Ref (MHz) Corrs
2011-06-15 15:33:52	INFO	listobs:..	0 128 TOPO 113211.988 15625 2000000 113204.175 XX YY
2011-06-15 15:33:52	INFO	listobs:..	1 128 TOPO 111450.813 15625 2000000 111443 XX YY
2011-06-15 15:33:52	INFO	listobs:..	2 128 TOPO 101506.187 15625 2000000 101514 XX YY
2011-06-15 15:33:52	INFO	listobs:..	3 128 TOPO 103050.863 15625 2000000 103058.675 XX YY
2011-06-15 15:33:52	INFO	listobs:..	Sources: 12
2011-06-15 15:33:52	INFO	listobs:..	ID Name SpwID RestFreq (MHz) SysVel (km/s)
2011-06-15 15:33:52	INFO	listobs:..	0 1037-295 0 - -
2011-06-15 15:33:52	INFO	listobs:..	0 1037-295 1 - -
2011-06-15 15:33:52	INFO	listobs:..	0 1037-295 2 - -
2011-06-15 15:33:52	INFO	listobs:..	0 1037-295 3 - -
2011-06-15 15:33:52	INFO	listobs:..	1 Titan 0 - -
2011-06-15 15:33:52	INFO	listobs:..	1 Titan 1 - -
2011-06-15 15:33:52	INFO	listobs:..	1 Titan 2 - -
2011-06-15 15:33:52	INFO	listobs:..	1 Titan 3 - -
2011-06-15 15:33:52	INFO	listobs:..	2 NGC3256 0 - -
2011-06-15 15:33:52	INFO	listobs:..	2 NGC3256 1 - -
2011-06-15 15:33:52	INFO	listobs:..	2 NGC3256 2 - -
2011-06-15 15:33:52	INFO	listobs:..	2 NGC3256 3 - -
2011-06-15 15:33:53	INFO	listobs:..	Antennas: 8:
2011-06-15 15:33:53	INFO	listobs:..	ID Name Station Diam. Long. Lat.
2011-06-15 15:33:53	INFO	listobs:..	0 DV04 J505 12.0 m -067.45.18.0 -22.53.22.8
2011-06-15 15:33:53	INFO	listobs:..	1 DV06 T704 12.0 m -067.45.16.2 -22.53.22.1
2011-06-15 15:33:53	INFO	listobs:..	2 DV07 J510 12.0 m -067.45.17.8 -22.53.23.5
2011-06-15 15:33:53	INFO	listobs:..	3 DV08 T703 12.0 m -067.45.16.2 -22.53.23.9
2011-06-15 15:33:53	INFO	listobs:..	4 DV09 N602 12.0 m -067.45.17.4 -22.53.22.3
2011-06-15 15:33:53	INFO	listobs:..	5 PM02 T701 12.0 m -067.45.18.8 -22.53.22.2
2011-06-15 15:33:53	INFO	listobs:..	6 PM03 J504 12.0 m -067.45.17.0 -22.53.23.0
2011-06-15 15:33:53	INFO	listobs:..	7 DV10 N606 12.0 m -067.45.17.1 -22.53.23.6
2011-06-15 15:33:53	INFO	listobs:..	listobs:::casa

Insert Message: Lock scroll

Data Examination and Flagging

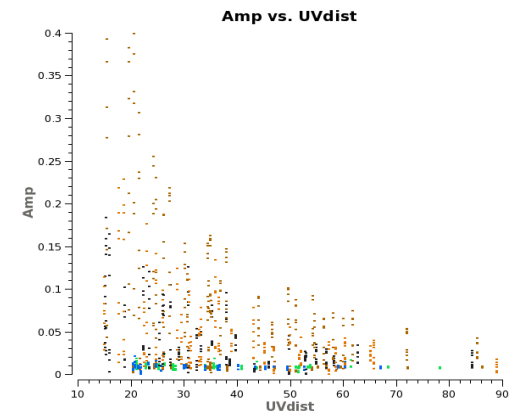
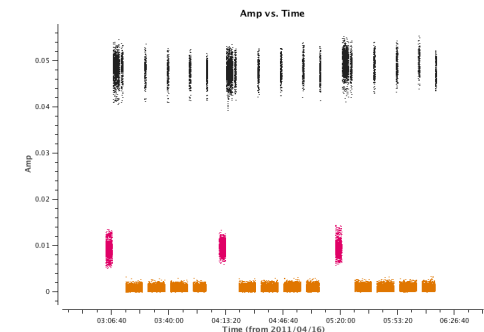
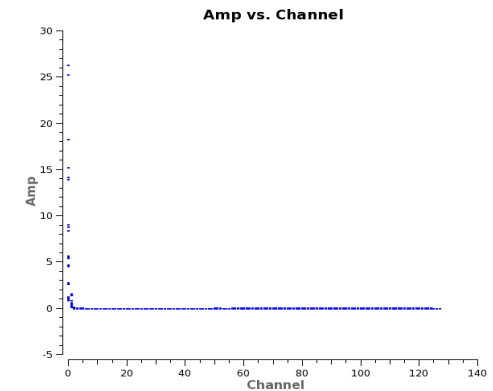
Data Examination (2)

- `plotms`

```
plotms(vis='ngc3256_line.ms', xaxis='channel', yaxis='amp',  
       averagedata=T, avgbaseline=T,  
       avgttime='1e8', avgscan=T)
```

```
plotms(vis='ngc3256_line.ms', xaxis='time', yaxis='amp',  
       averagedata=T, avgchannel='128', coloraxis='field',  
       iteraxis='spw')
```

```
plotms(vis='ngc3256_line.ms', xaxis='uvdist', yaxis='amp', field='1',  
       averagedata=T, avgchannel='128', avgttime='1e8',  
       coloraxis='scan')
```



Data Examination and Flagging

Data Editing

- `flagdata`

```
flagdata(vis=name+'.ms', mode = 'shadow')
```

```
flagdata(vis='ngc3256_line.ms', flagbackup=T, spw=['*:0~16', '*:125~127'])
```

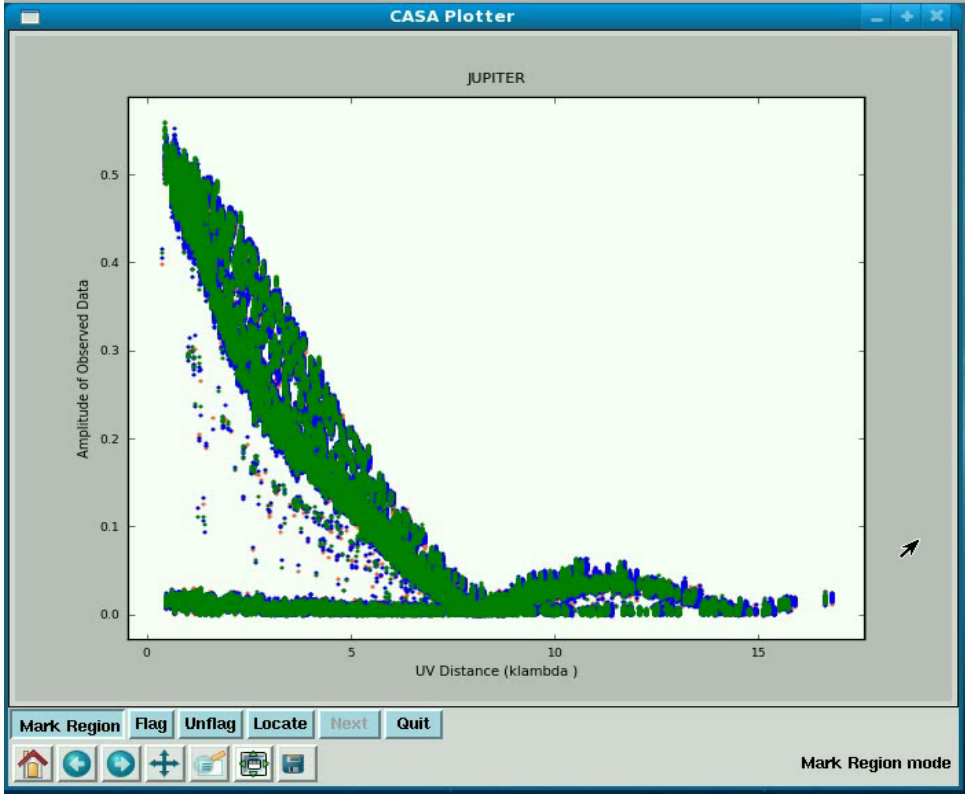
```
flagdata(vis = 'ngc3256_line.ms', flagbackup = T, timerange='>2011/04/16/12:00:00', field='Titan')
```

- `flagmanager`

```
flagmanager(vis = name+'.ms', mode = 'save', versionname = 'Apriori')
```

Log Messages (arcb101.ira.inaf.it:/arcfs0/homesarc/amignano/casapy.log) (on arcb101.ira.inaf.it)

Time	Priority	Origin	Message
2009-11-26 14:09:52	INFO	plotxy:::	Done Processing data ...
2009-11-26 14:09:52	INFO	plotxy:::ca..	
2009-11-26 14:09:52	INFO	plotxy:::ca..	##### Bnd Task: plotxy #####
2009-11-26 14:09:52	INFO	plotxy:::ca..	#####



IPy dataset/jupiter

```
File Edit View Terminal Tabs Help
Look in logger to see what it is
You see much is Antenna 9 (ID=8) in spw 1
Return to continue script
INFO2 Number of points being plotted : 139905

INFO2 Number of points being plotted : 5376
Total process time 4.93 sec.
Total wall clock time 5.55 sec.

-----
Plotting vs. time antenna='9' and spw='1'
Box up last 4 scans which are bad and Flag
Return to continue script
INFO2 Number of points being plotted : 2594

INFO2 Number of points being plotted : 71571
INFO2 Number of points being plotted : 68334
Total process time 6.46 sec.
Total wall clock time 7.26 sec.

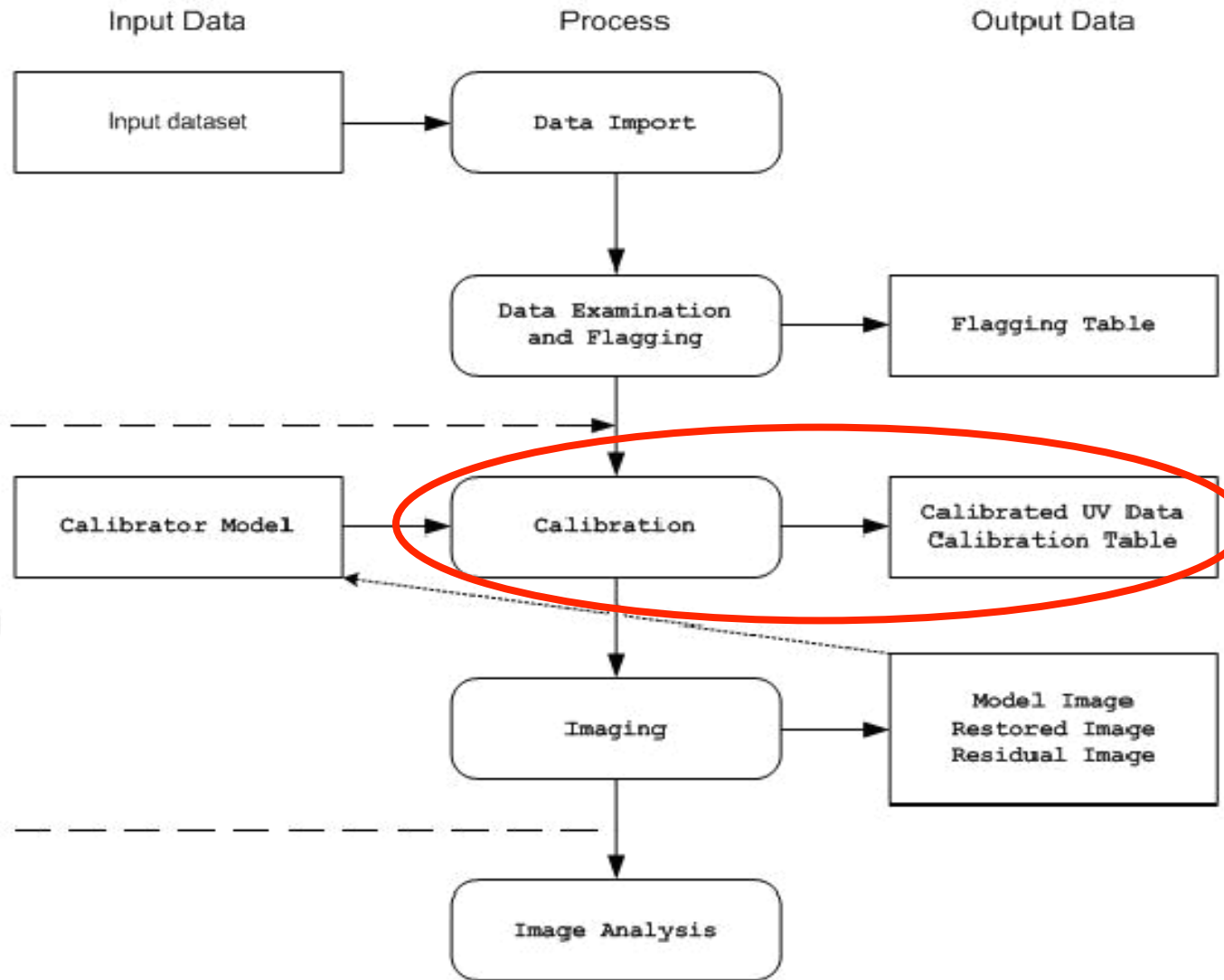
-----
Back to all data
Clean up remaining bad points

Return to continue script

INFO2 Number of points being plotted : 114750
INFO2 Number of points being plotted : 114750
Total process time 7.14 sec.
Total wall clock time 7.77 sec.

-----
Now plot JUPITER versus uvdist
Lots of bad stuff near bottom
Lets go and find it - try Locate
Looks like lots of different antennas but at same time
Return to continue script
```


Import



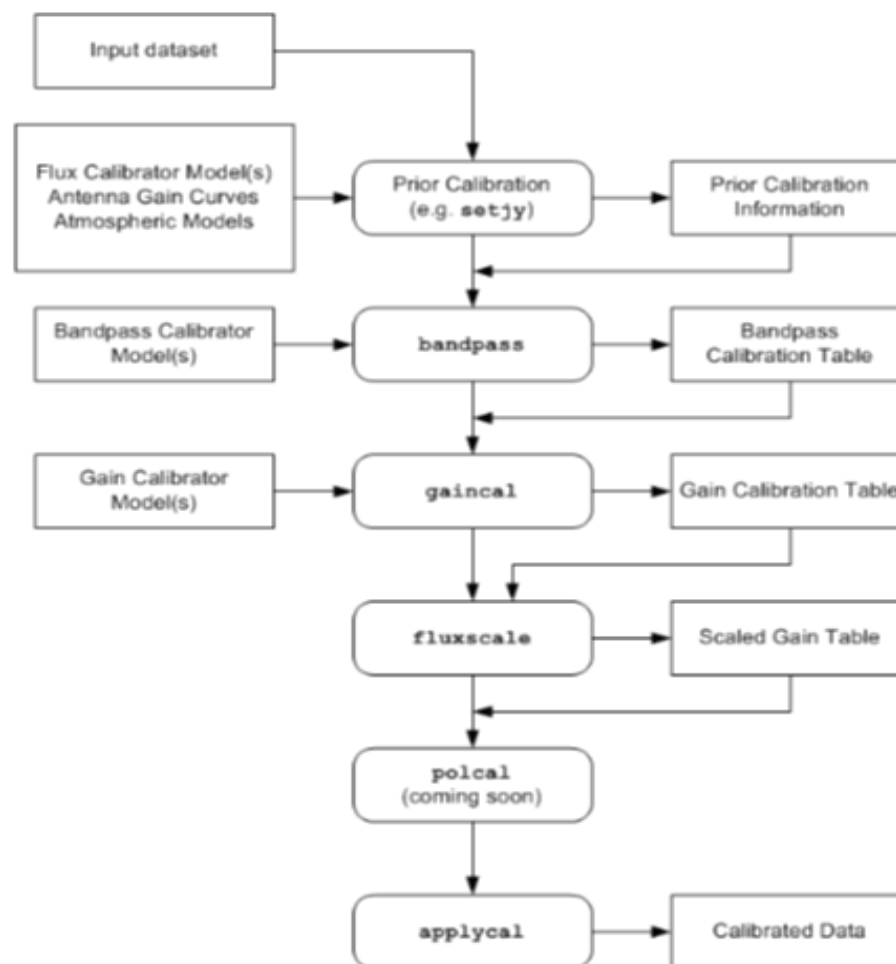
Examine

Calibrate

Image

Calibration in CASA

- prior calibration: **setjy**
- solvers: **gaincal**, **bandpass**, **blcal**, **fringecal**
- manipulation: **plotcal**, **accum**, **smoothcal**
- application: **applycal**, **split**
- other: **uvcontsub**, **uvmodelfit**

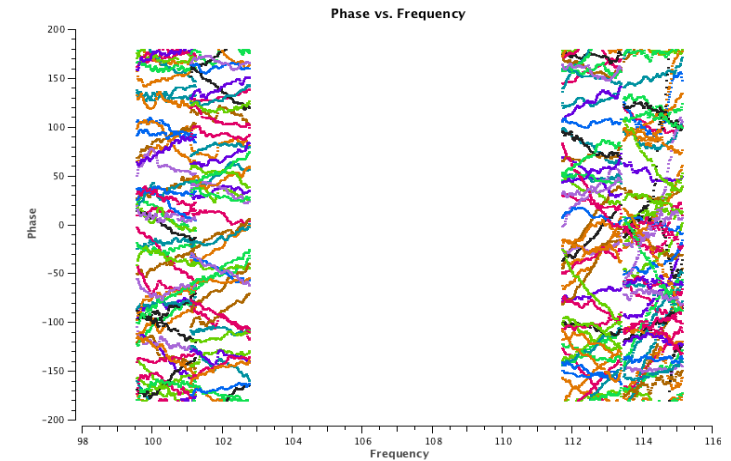


The Case of NGC3256

Data Calibration

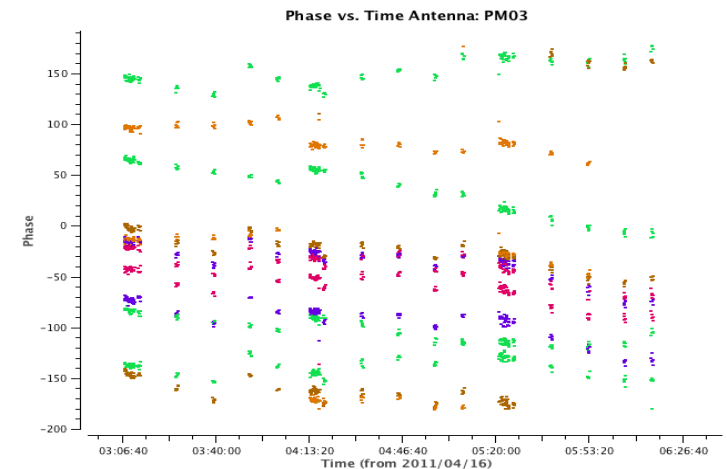
- bandpass (A,p vs freq)

```
bandpass(vis = 'ngc3256_line.ms', caltable = 'cal-ngc3256.B1', gaintable = 'cal-ngc3256.G1', timerange='<2011/04/16/15:00:00', field = '1037*', minblperant=3, minsnr=2, solint='inf', combine='scan', bandtype='B', fillgaps=1, refant = 'DV04', solnorm = T)
```



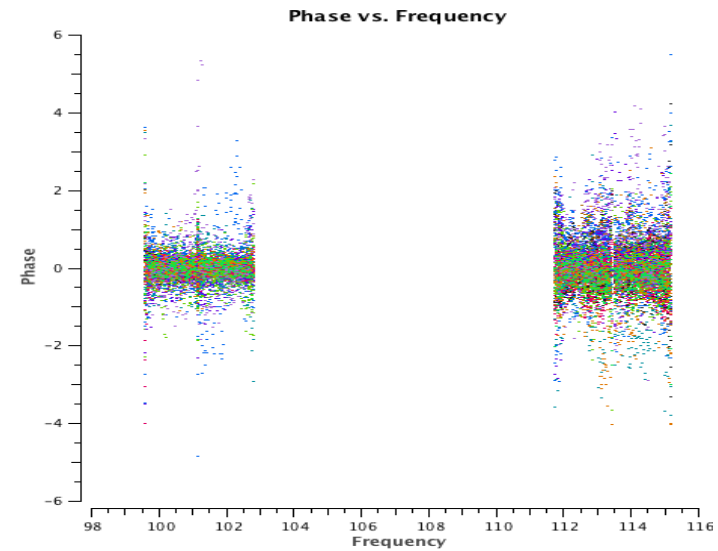
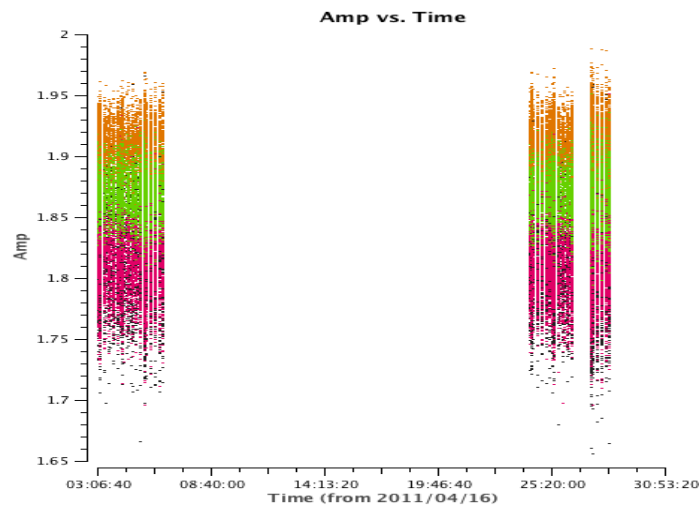
- gaincal (A,p vs time)

```
gaincal(vis = 'ngc3256_line.ms', caltable = 'cal-ngc3256.G2', spw = '*:16~112', field = '1037*,Titan', minsnr=1.0, solint='inf', selectdata=T, solnorm=False, refant = 'DV04', gaintable = 'cal-ngc3256.B1', calmode = 'ap')
```

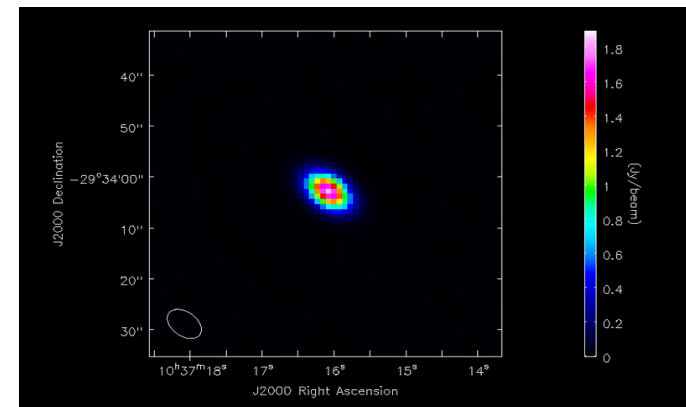


The Case of NGC3256

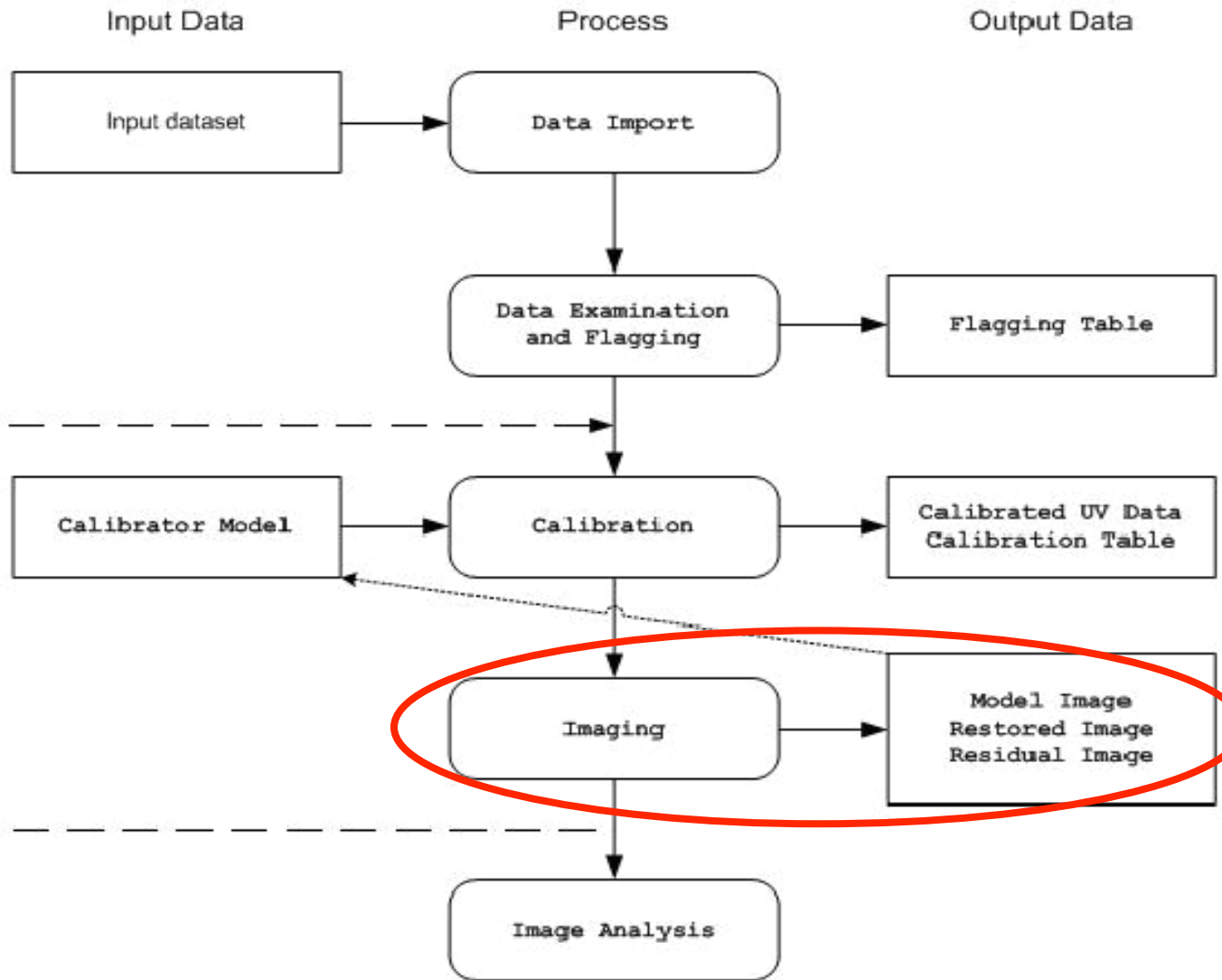
Data Calibration



- plotcal, setjy, fluxscale, applycal, split
- image the calibrator, why not?



Import



Examine

Calibrate

Image

Imaging in CASA

- task clean (variety of algorithms)
 - single-field cleaning
 - uses mosaic uv-gridder (uv-plane mosaicing on single image)
 - widefield imaging (apply W-Projection or faceting corrections)
- task feather: combine single-dish and uvMS

The Case of NGC3256

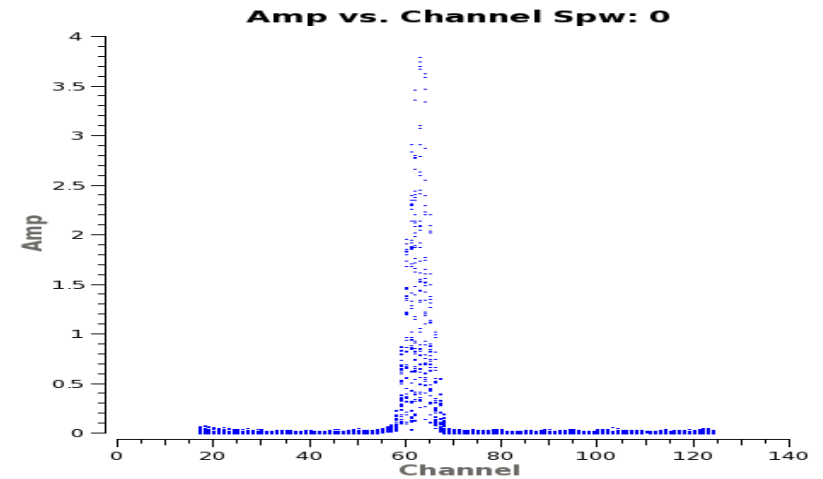
Imaging

- `uvcontsub`

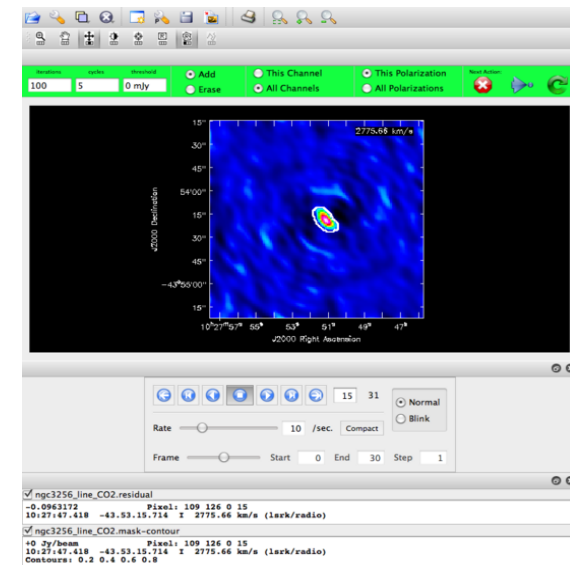
```
uvcontsub(vis = 'ngc3256_line_target_sc.ms',  
          fitspw='0:20~53;71~120,1:70~120,2:20~120,  
          3:20~120', fitorder = 1, fitmode = 'subtract')
```

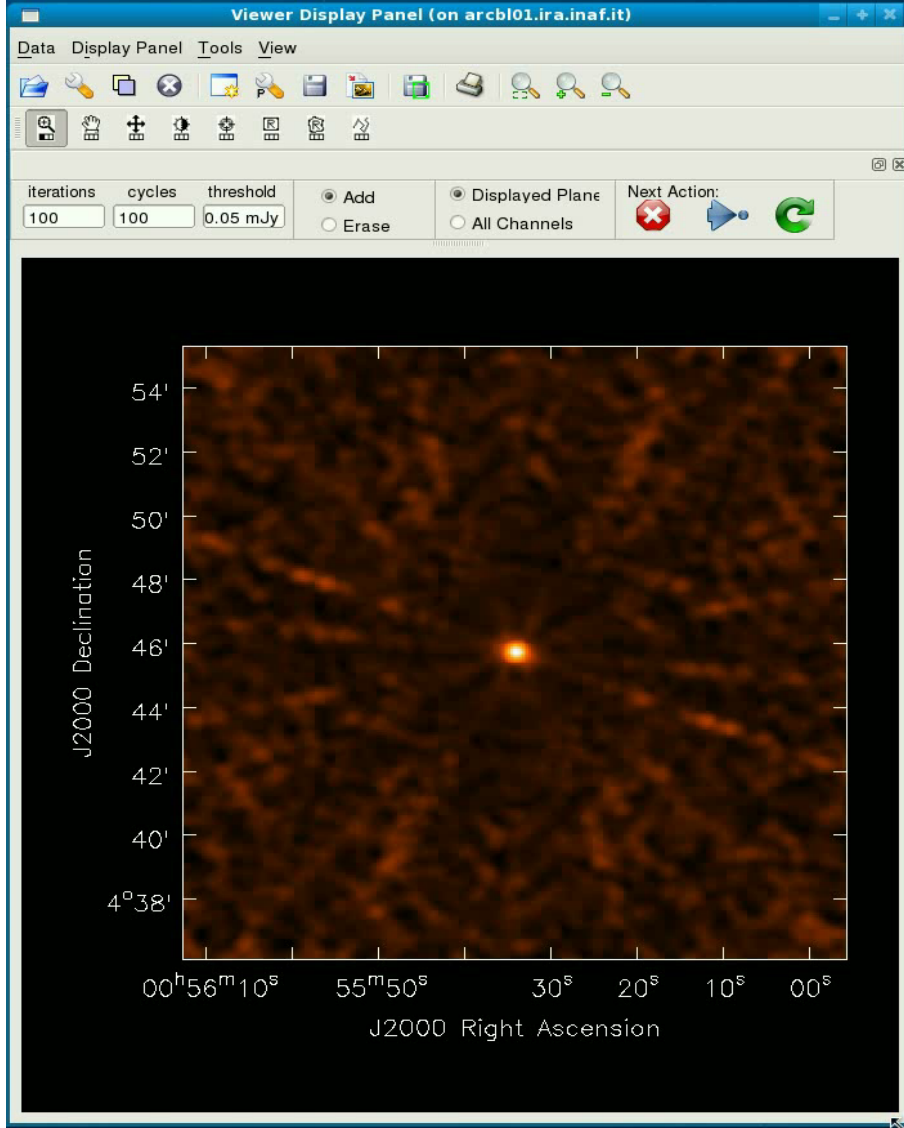
- `clean`

```
clean(vis='ngc3256_line_target_sc.ms', imagename=  
      'result-ngc3256_line_CO', spw='0:38~87', mode='channel',  
      start="", nchan=50, width="", psfmode='hogbom',  
      restfreq='115.27 GHz', mask=[53,50,87,83],  
      niter=500, interactive=T, imsize=128, cell='1arcsec',  
      weighting='briggs', robust=0.0, threshold='5mJy')
```



Amplitude vs. channel for spw 0/1. CN/CO lines.





```
Filter: Origin
4
987 (arcsec) at pa -40.4963 (deg)
Lock scroll
IPy dataset/jupiter
File Edit View Terminal Tabs Help
--PlotCal--
INFO2 Number of points being plotted : 2000
-----
Plotcal
Looking at amplitude in cal-table jupiter6cm.demo.fluxscale
Return to continue script
--Polcal (D)--
Solve for polarization leakage on 0137+331
Pretend it has unknown polarization
--Listcal (PoD)--
Listing calibration to file jupiter6cm.demo.pcal.list
Writing output to file: jupiter6cm.demo.pcal.list
--Plotcal (PoD)--
INFO2 Number of points being plotted : 108
These are the amplitudes of D-terms versus antenna
Return to continue script
--Setjy--
Use setjy to set IQU fluxes of 1331+305
--PolCal (X)--
Polarization R-L Phase Calibration (linear approx)
--ApplyCal--
This will apply the calibration to the DATA
Fills CORRECTED DATA
--Split Jupiter--
Split JUPITER data into new ms jupiter6cm.demo.JUPITER.split.ms
Split 0137+331 data into new ms jupiter6cm.demo.0137+331.split.ms
--Plotxy--
Calibration completed
--Clearcal--
Created scratch columns for MS jupiter6cm.demo.JUPITER.split.ms
--Clean 1--
Output images will be prefixed with jupiter6cm.demo.clean1
Will be a single MFS continuum image
```


The Case of NGC3256

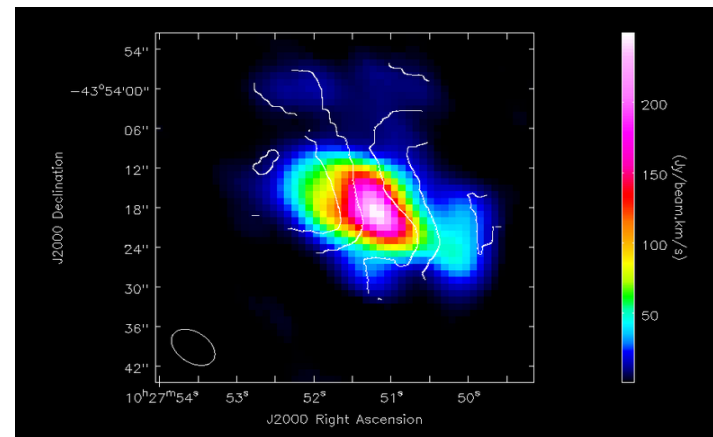
Analysis

- `immoments`
0-moment = line intensity
1-moment = line mean

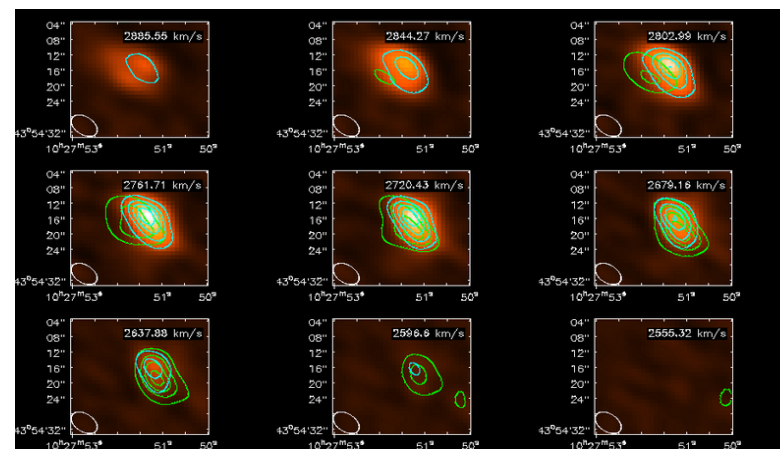
```
immoments(imagename='result-ngc3256_line_CO.image',  
           moments=[0], chans='15~34', box='38,38,90,90',  
           outfile='result-ngc3256_CO1-0.mom0')
```

- `imstat, imhead ...`

```
calstat = imstat (imagename='result-ngc3256_cont.image',  
                 region="", box='10,10,90,35')  
rms=(calstat['rms'])[0]
```



The CO(1-0) "moment 0" total intensity maps of NGC3256, with contours of the velocity field overlaid .



The 'hot metal' colours represent the higher frequency CN line the green contours are the CO line, and the cyan contours are the lower frequency CN line.

CASA on the Web

- <http://casa.nrao.edu> -- CASA Home Page
- Main resource for end users
 - <http://my.nrao.edu> -- NRAO Services (incl. registration/download of CASA)
- Help Desk/Installation Front; manned by scientists (ALMA, ARC, NAUG, etc) to handle front-line users support.

Casa Documentation

- CASA Analysis cookbook: http://casa.nrao.edu/Doc/Cookbook/casa_cookbook.pdf
- CASA User Reference Manual: <http://casa.nrao.edu/docs/casaref/CasaRef.html>
- Python: <http://python.org/doc> (e.g., see Tutorial for novices)
- IPython: <http://ipython.scipy.org/moin/Documentation>
- matplotlib: <http://matplotlib.sourceforge.net/>