Introduction to CASA and Data Structure

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CASA

- CASA is the offline data reduction package for ALMA and the (Jansky) VLA
    - data from other telescopes usually work, too, but not primary goal of CASA).
- Import/export data, edit, calibrate, image, analyze.
- Also supports single dish (based on ATNF's ASAP).
- CASA has many tasks and a LOT of tools.

CASA

- Easy to write scripts and tasks.
- Lots of documentation, reduction tutorials, helpdesk.
- CASA has some of the most sophisticated algorithms implemented (multi-scale clean, Taylor term expansion for wide bands, W-term projection, OTF mosaicing, etc.)
- It has an active Algorithm Research Group.

CASA

- Web site: http://casa.nrao.edu/
- Available for both Linux and Mac OS.
  - Make sure to subscribe to the CASA mailing list for announcements of new releases, workshops, etc… (casa-announce), or for critical bugs and code updates (casa-users) at:

    http://casa.nrao.edu/ → Getting Help → Mailing lists

CASA

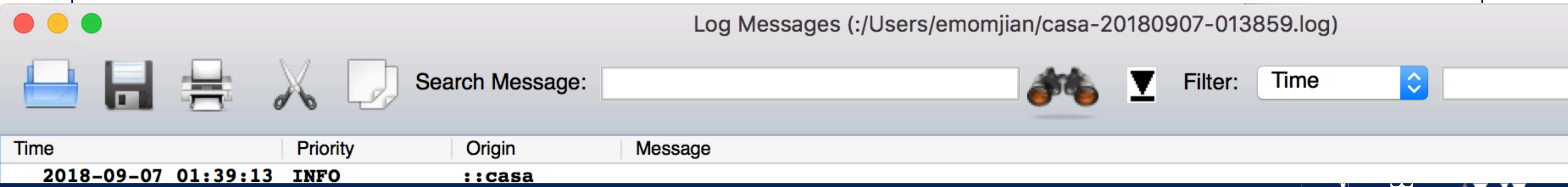
- Documentation is available at http://casa.nrao.edu/ → 'Documentation'
- Training material is available at http://casaguides.nrao.edu
- For help, use the NRAO help desk at: http://help.nrao.edu
  choose the 'CASA Data Reduction' Department

Outline

- CASA startup
- CASA basic python interface
- Tasks and tools
- The Measurement Set
- Data selection syntax
- Visualization tools
- Make your own task!

CASA Startup

```
> casa
==>
========================================
The start-up time of CASA may vary
depending on whether the shared libraries
are cached or not.
========================================
IPython 5.4.0 -- An enhanced Interactive Python.
CASA 5.4.0   -- Common Astronomy Software Applications

--> CrashReporter initialized.
Enter doc('start') for help getting started with CASA...
Using matplotlib backend: TkAgg

CASA <1>:
```



Log Messages (:/Users/emomjian/casa-20180907-013859.log)

```
Time                 Priority   Origin     Message
 2018-09-07 01:39:13  INFO       ::casa
```

CASA Interface

- Uses IPython for its command line interface:
  - Filesystem navigation, shell access
  - Namespace completion (<TAB>)
  - Session logging
    - ipython.log – ipython command history
    - casapy.log – casa messages
  - Numbered input/output with command history, full searching

Python Pointers

- to run a .py script:

  execfile('<scriptname>')

  example: execfile('ngc5921_demo.py')
- indentation matters!
  - be careful when doing cut-and-paste to Python
  - cut a few (4-6) lines at a time
- Python counts from 0 to n-1!
- variables are global when using *task interface*
- Task names are objects (not variables)

Tasks and tools in CASA

- Tasks - high-level functionality, well difined purpose
  - function call or parameter handling interface
  - these are what you should use in tutorial
- Tools - complete functionality
  - tool.method calls, used by tasks
  - sometimes shown in tutorial scripts

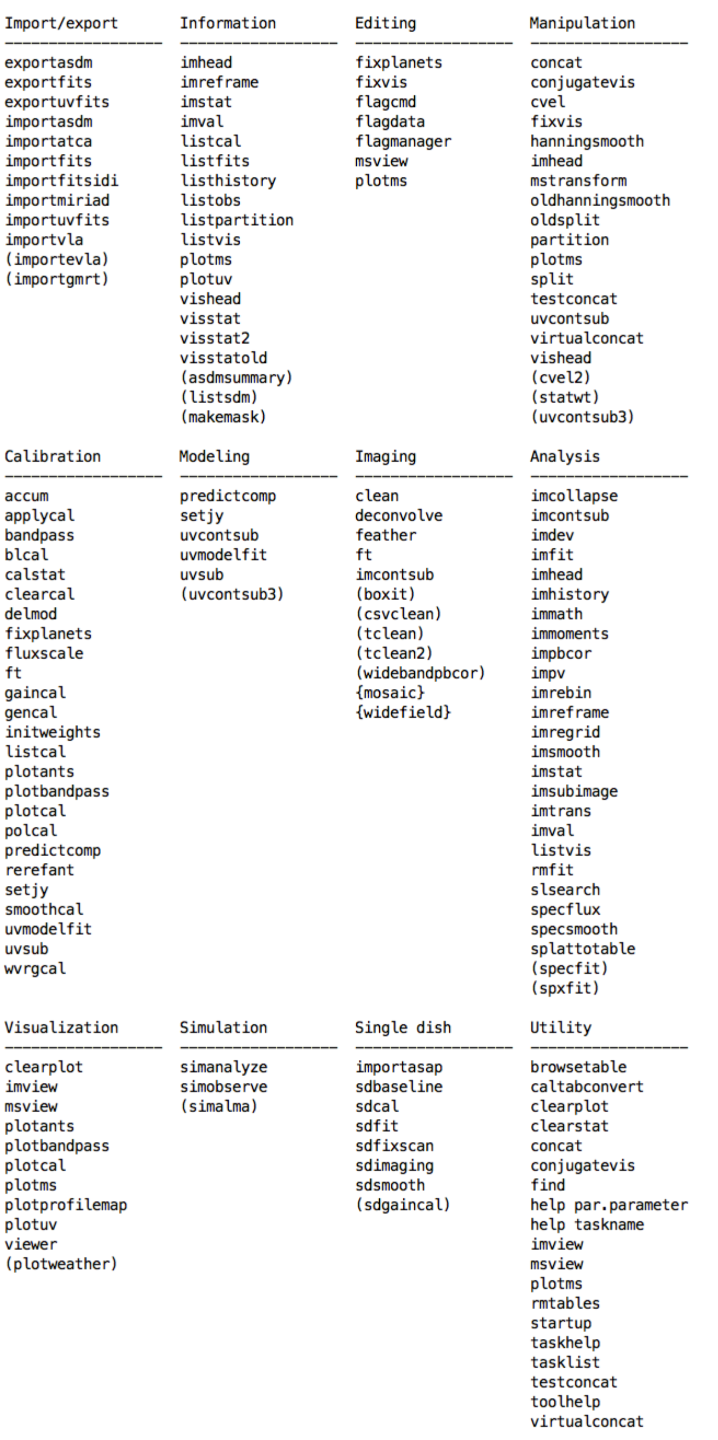
- Shell commands can be run with a leading exclamation mark !du –hs

CASA

- All CASA tasks can be listed by *tasklist.*
- The tasks are grouped as:
  - Import/export
  - Information
  - Editing
  - Manipulation
  - Calibration
  - Modeling
  - Imaging
  - Analysis
  - Visualization
  - Simulation
  - Single dish
  - Utility
- AIPS – CASA dictionary is available at https://safe.nrao.edu/wiki/bin/view/Software/CASA-AIPSDictionary

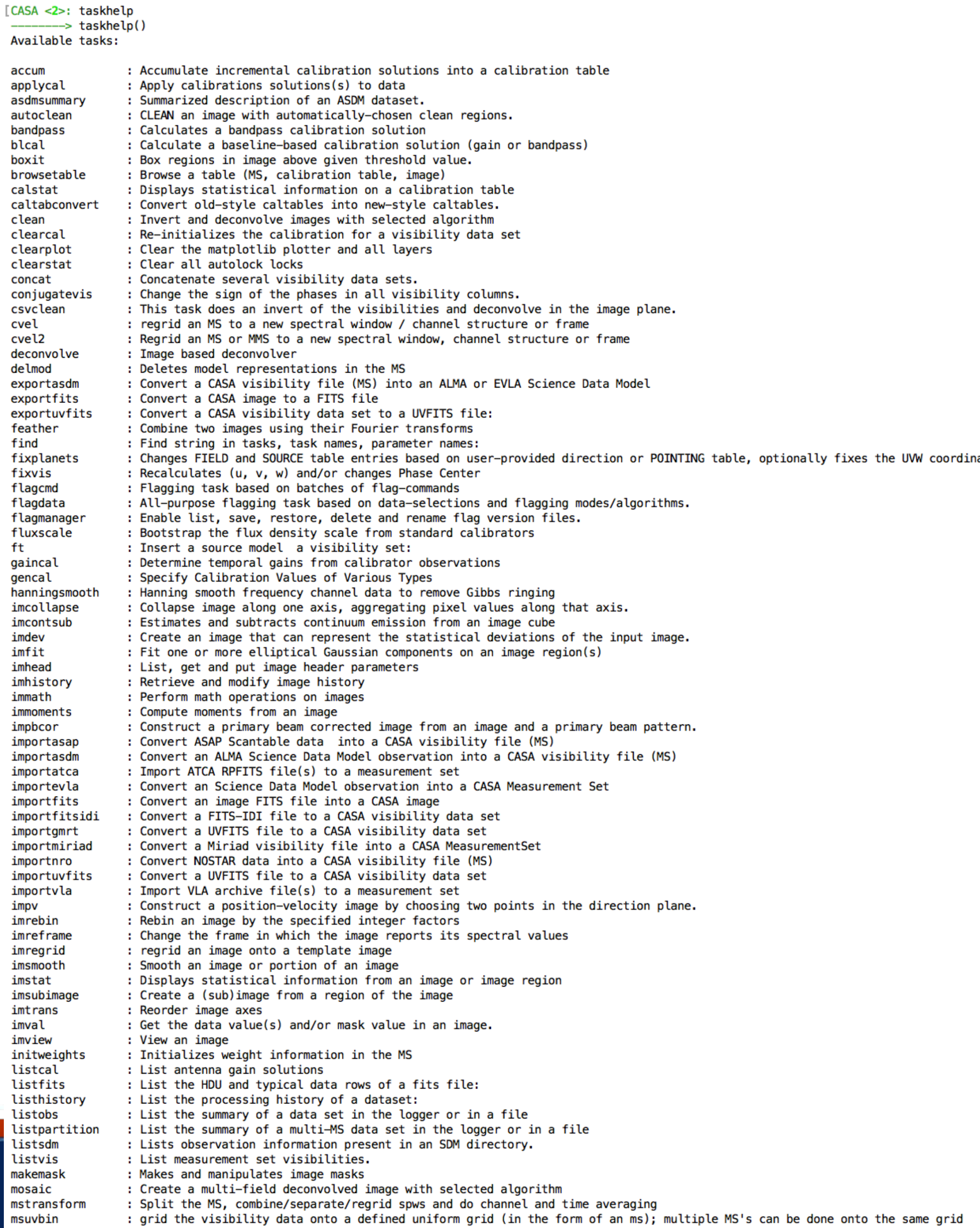
Tasks

To list the tasks: *tasklist*



```
Import/export       Information         Editing             Manipulation
------------------  ------------------  ------------------  ------------------
exportasdm          imhead              fixplanets          concat
exportfits          imreframe           fixvis              conjugatevis
exportuvfits        imstat              flagcmd             cvel
importasdm          imval               flagdata            fixvis
importatca          listcal             flagmanager         hanningsmooth
importfits          listfits            msview              imhead
importfitsidi       listhistory         plotms              mstransform
importmiriad        listobs                                 oldhanningsmooth
importuvfits        listpartition                           oldsplit
importvla           listvis                                 partition
(importevla)        plotms                                  plotms
(importgmrt)        plotuv                                  split
                    vishead                                 testconcat
                    visstat                                 uvcontsub
                    visstat2                                virtualconcat
                    visstatold                              vishead
                    (asdmsummary)                           (cvel2)
                    (listsdm)                               (statwt)
                    (makemask)                              (uvcontsub3)

Calibration         Modeling            Imaging             Analysis
------------------  ------------------  ------------------  ------------------
accum               predictcomp         clean               imcollapse
applycal            setjy               deconvolve          imcontsub
bandpass            uvcontsub           feather             imdev
blcal               uvmodelfit          ft                  imfit
calstat             uvsub               imcontsub           imhead
clearcal            (uvcontsub3)        (boxit)             imhistory
delmod                                  (csvclean)          immath
fixplanets                              (tclean)            immoments
fluxscale                               (tclean2)           impbcor
ft                                      (widebandpbcor)     impv
gaincal                                 {mosaic}            imrebin
gencal                                  {widefield}         imreframe
initweights                                                 imregrid
listcal                                                     imsmooth
plotants                                                    imstat
plotbandpass                                                imsubimage
plotcal                                                     imtrans
polcal                                                      imval
predictcomp                                                 listvis
rerefant                                                    rmfit
setjy                                                       slsearch
smoothcal                                                   specflux
uvmodelfit                                                  specsmooth
uvsub                                                       splattotable
wvrgcal                                                     (specfit)
                                                            (spxfit)

Visualization       Simulation          Single dish         Utility
------------------  ------------------  ------------------  ------------------
clearplot           simanalyze          importasap          browsetable
imview              simobserve          sdbaseline          caltabconvert
msview              (simalma)           sdcal               clearplot
plotants                                sdfit               clearstat
plotbandpass                            sdfixscan           concat
plotcal                                 sdimaging           conjugatevis
plotms                                  sdsmooth            find
plotprofilemap                          (sdgaincal)         help par.parameter
plotuv                                                      help taskname
viewer                                                      imview
(plotweather)                                               msview
                                                            plotms
                                                            rmtables
                                                            startup
                                                            taskhelp
                                                            tasklist
                                                            testconcat
                                                            toolhelp
                                                            virtualconcat
```

To see list of tasks with short help: *taskhelp*



```
[CASA <2>: taskhelp
--------> taskhelp()
Available tasks:

accum            : Accumulate incremental calibration solutions into a calibration table
applycal         : Apply calibrations solutions(s) to data
asdmsummary      : Summarized description of an ASDM dataset.
autoclean        : CLEAN an image with automatically-chosen clean regions.
bandpass         : Calculates a bandpass calibration solution
blcal            : Calculate a baseline-based calibration solution (gain or bandpass)
boxit            : Box regions in image above given threshold value.
browsetable      : Browse a table (MS, calibration table, image)
calstat          : Displays statistical information on a calibration table
caltabconvert    : Convert old-style caltables into new-style caltables.
clean            : Invert and deconvolve images with selected algorithm
clearcal         : Re-initializes the calibration for a visibility data set
clearplot        : Clear the matplotlib plotter and all layers
clearstat        : Clear all autolock locks
concat           : Concatenate several visibility data sets.
conjugatevis     : Change the sign of the phases in all visibility columns.
csvclean         : This task does an invert of the visibilities and deconvolve in the image plane.
cvel             : regrid an MS to a new spectral window / channel structure or frame
cvel2            : Regrid an MS or MMS to a new spectral window, channel structure or frame
deconvolve       : Image based deconvolver
delmod           : Deletes model representations in the MS
exportasdm       : Convert a CASA visibility file (MS) into an ALMA or EVLA Science Data Model
exportfits       : Convert a CASA image to a FITS file
exportuvfits     : Convert a CASA visibility data set to a UVFITS file:
feather          : Combine two images using their Fourier transforms
find             : Find string in tasks, task names, parameter names:
fixplanets       : Changes FIELD and SOURCE table entries based on user-provided direction or POINTING table, optionally fixes the UVW coordina
fixvis           : Recalculates (u, v, w) and/or changes Phase Center
flagcmd          : Flagging task based on batches of flag-commands
flagdata         : All-purpose flagging task based on data-selections and flagging modes/algorithms.
flagmanager      : Enable list, save, restore, delete and rename flag version files.
fluxscale        : Bootstrap the flux density scale from standard calibrators
ft               : Insert a source model  a visibility set:
gaincal          : Determine temporal gains from calibrator observations
gencal           : Specify Calibration Values of Various Types
hanningsmooth    : Hanning smooth frequency channel data to remove Gibbs ringing
imcollapse       : Collapse image along one axis, aggregating pixel values along that axis.
imcontsub        : Estimates and subtracts continuum emission from an image cube
imdev            : Create an image that can represent the statistical deviations of the input image.
imfit            : Fit one or more elliptical Gaussian components on an image region(s)
imhead           : List, get and put image header parameters
imhistory        : Retrieve and modify image history
immath           : Perform math operations on images
immoments        : Compute moments from an image
impbcor          : Construct a primary beam corrected image from an image and a primary beam pattern.
importasap       : Convert ASAP Scantable data  into a CASA visibility file (MS)
importasdm       : Convert an ALMA Science Data Model observation into a CASA visibility file (MS)
importatca       : Import ATCA RPFITS file(s) to a measurement set
importevla       : Convert an Science Data Model observation into a CASA Measurement Set
importfits       : Convert an image FITS file into a CASA image
importfitsidi    : Convert a FITS-IDI file to a CASA visibility data set
importgmrt       : Convert a UVFITS file to a CASA visibility data set
importmiriad     : Convert a Miriad visibility file into a CASA MeasurementSet
importnro        : Convert NOSTAR data into a CASA visibility file (MS)
importuvfits     : Convert a UVFITS file to a CASA visibility data set
importvla        : Import VLA archive file(s) to a measurement set
impv             : Construct a position-velocity image by choosing two points in the direction plane.
imrebin          : Rebin an image by the specified integer factors
imreframe        : Change the frame in which the image reports its spectral values
imregrid         : regrid an image onto a template image
imsmooth         : Smooth an image or portion of an image
imstat           : Displays statistical information from an image or image region
imsubimage       : Create a (sub)image from a region of the image
imtrans          : Reorder image axes
imval            : Get the data value(s) and/or mask value in an image.
imview           : View an image
initweights      : Initializes weight information in the MS
listcal          : List antenna gain solutions
listfits         : List the HDU and typical data rows of a fits file:
listhistory      : List the processing history of a dataset:
listobs          : List the summary of a data set in the logger or in a file
listpartition    : List the summary of a multi-MS data set in the logger or in a file
listsdm          : Lists observation information present in an SDM directory.
listvis          : List measurement set visibilities.
makemask         : Makes and manipulates image masks
mosaic           : Create a multi-field deconvolved image with selected algorithm
mstransform      : Split the MS, combine/separate/regrid spws and do channel and time averaging
msuvbin          : grid the visibility data onto a defined uniform grid (in the form of an ms); multiple MS's can be done onto the same grid
```

Task Interface

- parameters are set as global Python variables

  (set) <param> = <value>

  (e.g. , vis = ‘ngc5921.demo.ms’)
- using inp, default, saveinputs, tget, tput
- execute

  <taskname> or go (e.g. clean())

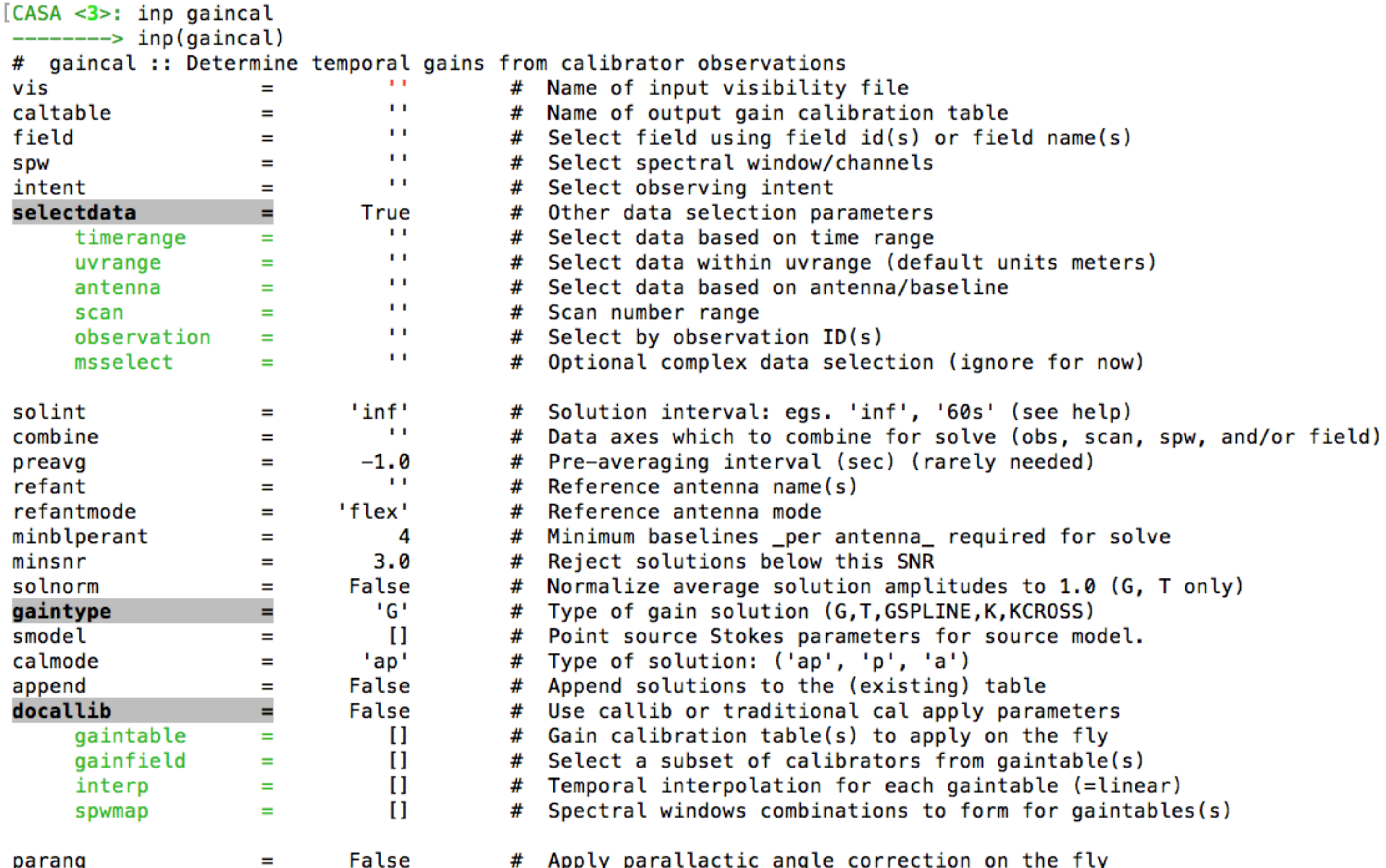
Task Interface

Call a task by

>inp <*taskname*>

if default values are desired, first type

>default <*taskname*>, followed by inp



```
[CASA <3>: inp gaincal
 --------> inp(gaincal)
#  gaincal :: Determine temporal gains from calibrator observations
vis                 =         ''        #  Name of input visibility file
caltable            =         ''        #  Name of output gain calibration table
field               =         ''        #  Select field using field id(s) or field name(s)
spw                 =         ''        #  Select spectral window/channels
intent              =         ''        #  Select observing intent
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
     observation    =         ''        #  Select by observation ID(s)
     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 (obs, scan, spw, and/or field)
preavg              =       -1.0        #  Pre-averaging interval (sec) (rarely needed)
refant              =         ''        #  Reference antenna name(s)
refantmode          =     'flex'        #  Reference antenna mode
minblperant         =          4        #  Minimum baselines _per antenna_ required for solve
minsnr              =        3.0        #  Reject solutions below this SNR
solnorm             =      False        #  Normalize average solution amplitudes to 1.0 (G, T only)
gaintype            =        'G'        #  Type of gain solution (G,T,GSPLINE,K,KCROSS)
smodel              =         []        #  Point source Stokes parameters for source model.
calmode             =       'ap'        #  Type of solution: ('ap', 'p', 'a')
append              =      False        #  Append solutions to the (existing) table
docallib            =      False        #  Use callib or traditional cal apply parameters
     gaintable      =         []        #  Gain calibration table(s) to apply on the fly
     gainfield      =         []        #  Select a subset of calibrators from gaintable(s)
     interp         =         []        #  Temporal interpolation for each gaintable (=linear)
     spwmap         =         []        #  Spectral windows combinations to form for gaintables(s)

parang              =      False        #  Apply parallactic angle correction on the fly
```

Task Execution

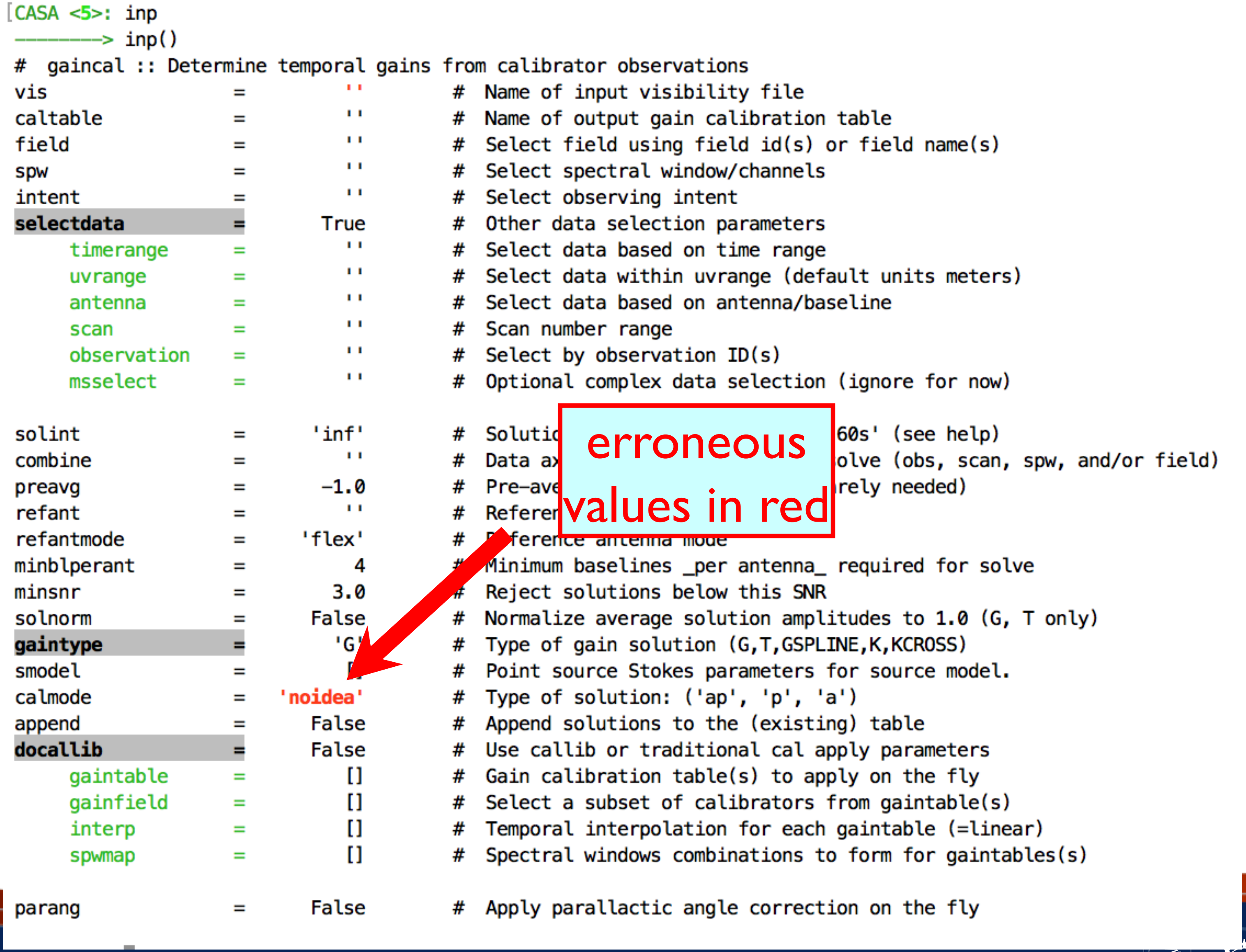
- Two ways to invoke:
  - call from Python as functions with arguments

    ```
    taskname( arg1=val1, arg2=val2, ... ), like
    ```

    ```
    clean(vis= ‘input.ms’ ,
      imagename= ‘galaxy’ ,selectvis=T, robust=0.5,
      imsize=[200,200])
    ```

    unspecified parameters will be defaulted
  - use standard tasking interface.

Parameter Checking



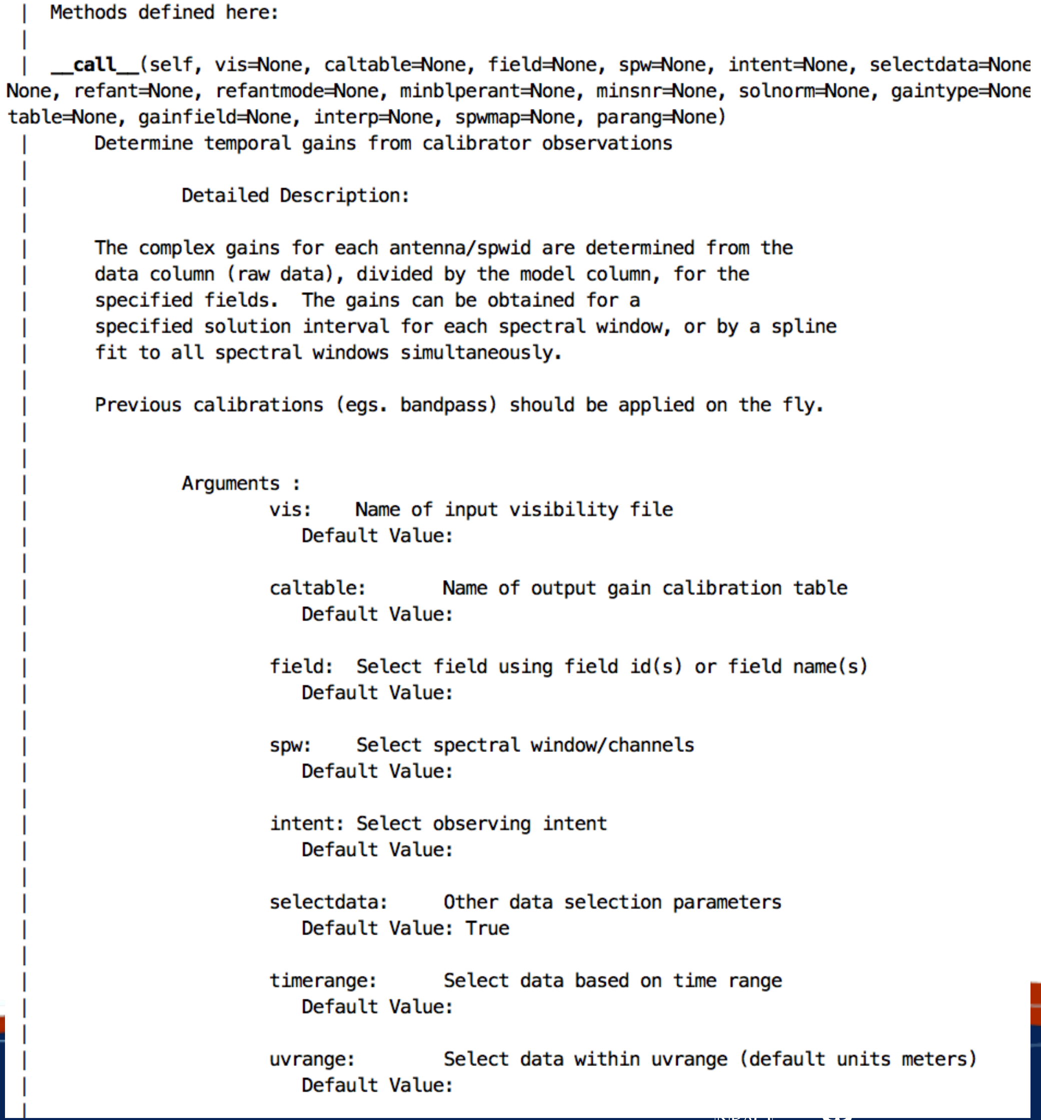
```
CASA <5>: inp
--------> inp()
#  gaincal :: Determine temporal gains from calibrator observations
vis                 =         ''        #  Name of input visibility file
caltable            =         ''        #  Name of output gain calibration table
field               =         ''        #  Select field using field id(s) or field name(s)
spw                 =         ''        #  Select spectral window/channels
intent              =         ''        #  Select observing intent
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
     observation    =         ''        #  Select by observation ID(s)
     msselect       =         ''        #  Optional complex data selection (ignore for now)

solint              =      'inf'        #  Solutic            60s' (see help)
combine             =         ''        #  Data ax            olve (obs, scan, spw, and/or field)
preavg              =       -1.0        #  Pre-ave            rely needed)
refant              =         ''        #  Referer
refantmode          =     'flex'        #  Reference antenna mode
minblperant         =          4        #  Minimum baselines _per antenna_ required for solve
minsnr              =        3.0        #  Reject solutions below this SNR
solnorm             =      False        #  Normalize average solution amplitudes to 1.0 (G, T only)
gaintype            =        'G'        #  Type of gain solution (G,T,GSPLINE,K,KCROSS)
smodel              =         []        #  Point source Stokes parameters for source model.
calmode             =   'noidea'        #  Type of solution: ('ap', 'p', 'a')
append              =      False        #  Append solutions to the (existing) table
docallib            =      False        #  Use callib or traditional cal apply parameters
     gaintable      =         []        #  Gain calibration table(s) to apply on the fly
     gainfield      =         []        #  Select a subset of calibrators from gaintable(s)
     interp         =         []        #  Temporal interpolation for each gaintable (=linear)
     spwmap         =         []        #  Spectral windows combinations to form for gaintables(s)

parang              =      False        #  Apply parallactic angle correction on the fly
```

erroneous values in red

Help on Tasks

In-line help for all tasks (help <taskname>)

>help gaincal



```
 |  Methods defined here:
 |
 |  __call__(self, vis=None, caltable=None, field=None, spw=None, intent=None, selectdata=None
None, refant=None, refantmode=None, minblperant=None, minsnr=None, solnorm=None, gaintype=None
table=None, gainfield=None, interp=None, spwmap=None, parang=None)
 |      Determine temporal gains from calibrator observations
 |
 |              Detailed Description:
 |
 |      The complex gains for each antenna/spwid are determined from the
 |      data column (raw data), divided by the model column, for the
 |      specified fields.  The gains can be obtained for a
 |      specified solution interval for each spectral window, or by a spline
 |      fit to all spectral windows simultaneously.
 |
 |      Previous calibrations (egs. bandpass) should be applied on the fly.
 |
 |
 |              Arguments :
 |                      vis:    Name of input visibility file
 |                         Default Value:
 |
 |                      caltable:       Name of output gain calibration table
 |                         Default Value:
 |
 |                      field:  Select field using field id(s) or field name(s)
 |                         Default Value:
 |
 |                      spw:    Select spectral window/channels
 |                         Default Value:
 |
 |                      intent: Select observing intent
 |                         Default Value:
 |
 |                      selectdata:     Other data selection parameters
 |                         Default Value: True
 |
 |                      timerange:      Select data based on time range
 |                         Default Value:
 |
 |                      uvrange:        Select data within uvrange (default units meters)
 |                         Default Value:
 |
```

Tools in CASA

- What if there’s no task?

→use CASA tools (tasks are built upon tools)

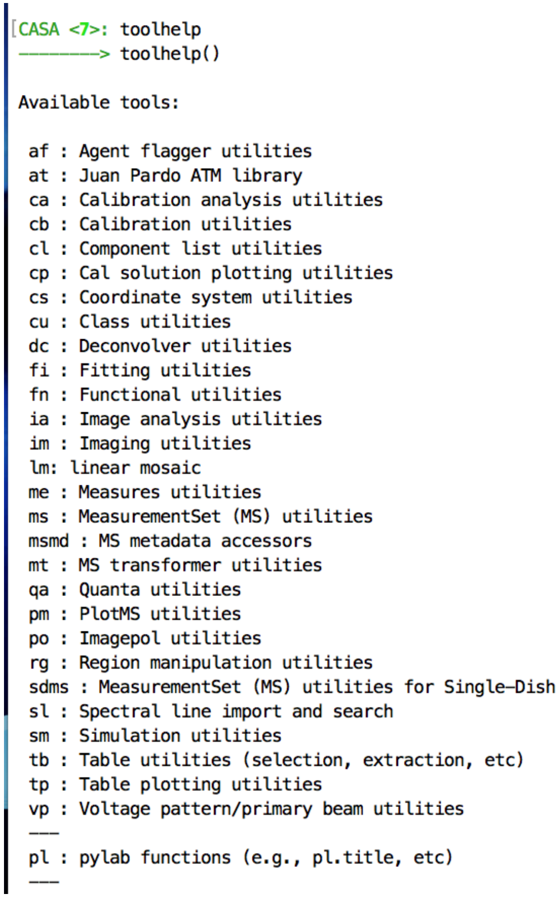
- tools are functions/methods
  - call from casapy as <tool>.<method>()
  - default tool objects are pre-constructed
    - e.g. imager (im) , calibrater (cb), ms (ms) , etc. (see toolhelp)

CASA Tool List

To list the default tools:

>toolhelp

~1000 tools available

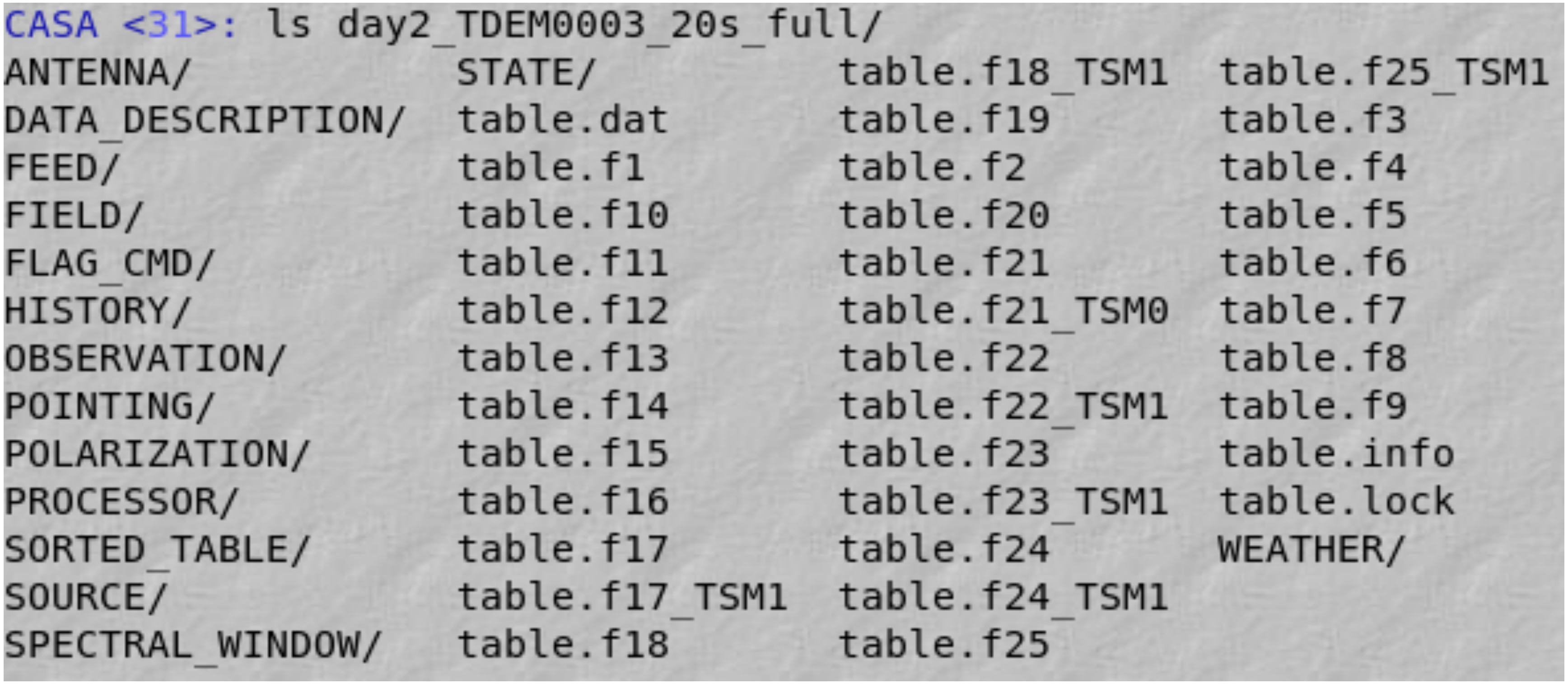


```
[CASA <7>: toolhelp
--------> toolhelp()

Available tools:

 af : Agent flagger utilities
 at : Juan Pardo ATM library
 ca : Calibration analysis utilities
 cb : Calibration utilities
 cl : Component list utilities
 cp : Cal solution plotting utilities
 cs : Coordinate system utilities
 cu : Class utilities
 dc : Deconvolver utilities
 fi : Fitting utilities
 fn : Functional utilities
 ia : Image analysis utilities
 im : Imaging utilities
 lm: linear mosaic
 me : Measures utilities
 ms : MeasurementSet (MS) utilities
 msmd : MS metadata accessors
 mt : MS transformer utilities
 qa : Quanta utilities
 pm : PlotMS utilities
 po : Imagepol utilities
 rg : Region manipulation utilities
 sdms : MeasurementSet (MS) utilities for Single-Dish
 sl : Spectral line import and search
 sm : Simulation utilities
 tb : Table utilities (selection, extraction, etc)
 tp : Table plotting utilities
 vp : Voltage pattern/primary beam utilities
 ---
 pl : pylab functions (e.g., pl.title, etc)
 ---
```

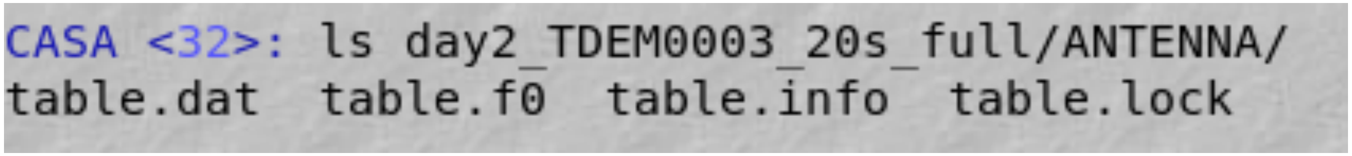
The Measurement Set

- The MS is a directory on disk, it consists of a MAIN table and sub-tables.
  - The MAIN table contains the visibility data. It consists of the `table.*` files.
  - The sub-tables (e.g. FIELD, SOURCE, ANTENNA, etc.) contain auxiliary and secondary information.
  - The sub-tables are sub-directories.
- To copy: must use cp -rf to get contents
- Best to remove MS with rmtables(‘filename’)

Example MS



```
CASA <31>: ls day2_TDEM0003_20s_full/
ANTENNA/             STATE/           table.f18_TSM1  table.f25_TSM1
DATA_DESCRIPTION/    table.dat        table.f19       table.f3
FEED/                table.f1         table.f2        table.f4
FIELD/               table.f10        table.f20       table.f5
FLAG_CMD/            table.f11        table.f21       table.f6
HISTORY/             table.f12        table.f21_TSM0  table.f7
OBSERVATION/         table.f13        table.f22       table.f8
POINTING/            table.f14        table.f22_TSM1  table.f9
POLARIZATION/        table.f15        table.f23       table.info
PROCESSOR/           table.f16        table.f23_TSM1  table.lock
SORTED_TABLE/        table.f17        table.f24       WEATHER/
SOURCE/              table.f17_TSM1   table.f24_TSM1
SPECTRAL_WINDOW/     table.f18        table.f25
```



```
CASA <32>: ls day2_TDEM0003_20s_full/ANTENNA/
table.dat  table.f0  table.info  table.lock
```

Data Selection Syntax

- field - string with source name or field ID
  - can use ‘*’ as wildcard, first checks for name, then ID
  - example: field = ‘1331+305’ ; field = ‘3C*’ ; field = ‘0,1,4~5’
- spw - string with spectral window ID plus channels
  - use ‘:’ as separator of spw from optional channelization
  - example: spw = ‘0~2’ ; spw = ‘1:10~30’

Selection Syntax

– antenna - string with antenna name or ID
  - first check for name, then pad name, then ID
  - example: antenna = ‘1~5,11’ ; antenna = ‘ea*’, ‘!ea01’
  - For a baseline, use: antenna = ‘ea01&ea10’

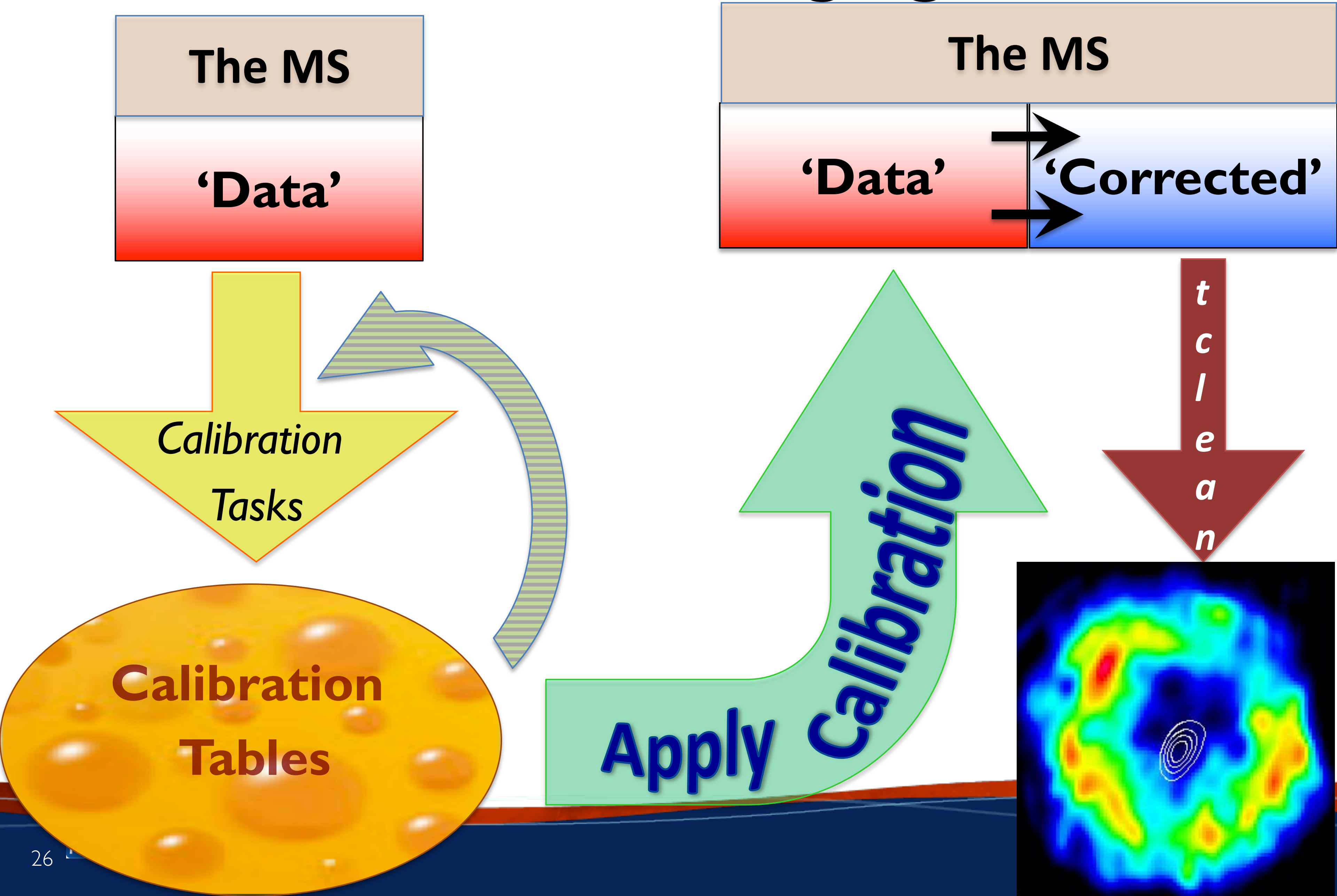
– timerange - string with date/time range
  - specify ‘T0~T1’, missing parts of T1 default to T0.
  - example: timerange = ‘2007/10/16/01:00:00~06:30:00’
  - If year, month, day are not specified → defaults to 1st day in the data set.

The MS structure

‘Data’ column	**‘Corrected’ Column**	**‘Model’ Column**
Raw Data	Calibrated Data	FT of source model

- When you load your data from the archive, your MS will only have the ‘Data’ column.
- The other two columns can be created by various means.
- The creation of the other two columns → MS tripling in size.

Calibration & Imaging Flow



The MS

'Data'

Calibration Tasks

Calibration Tables

Apply Calibration

The MS

'Data'

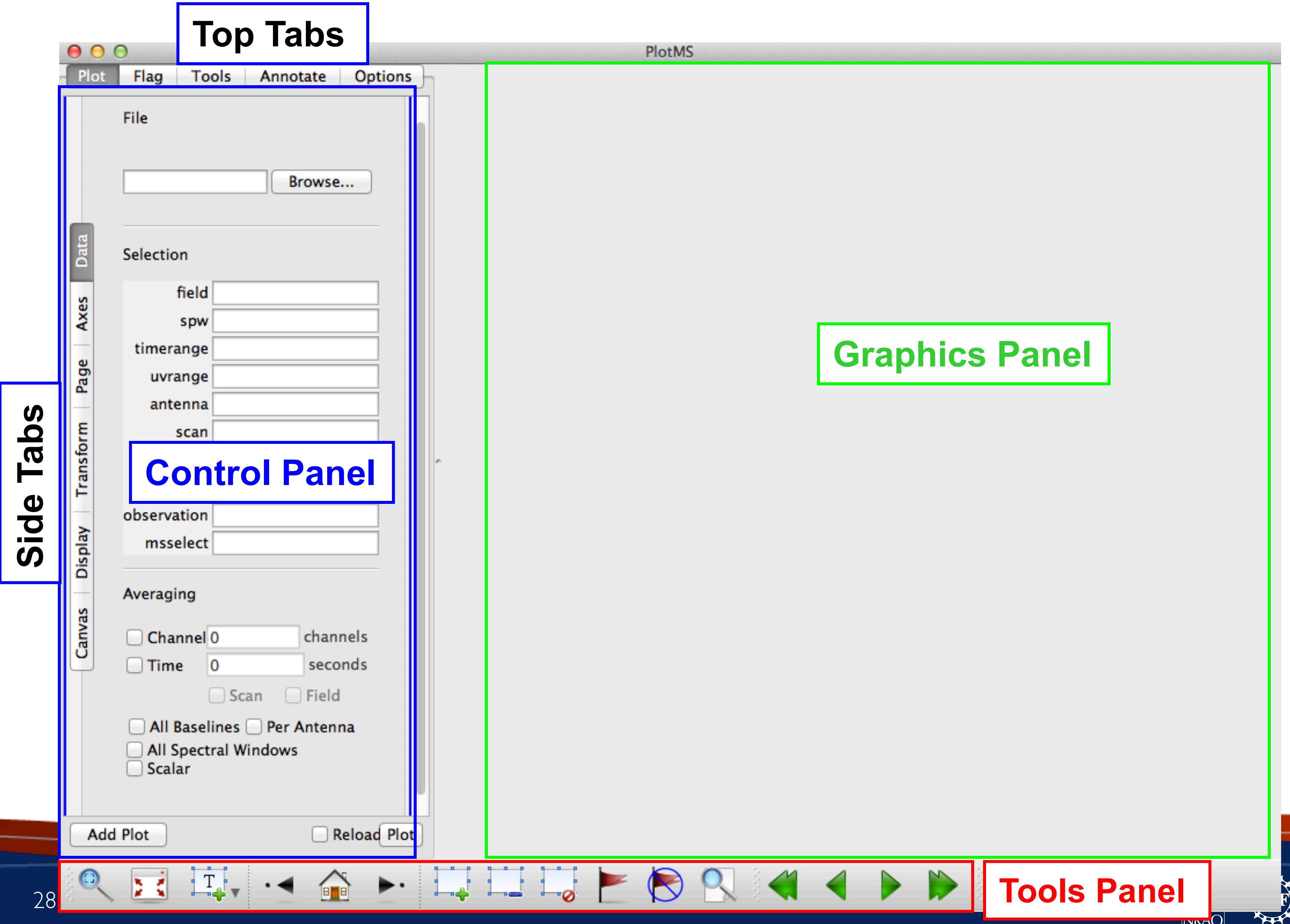
'Corrected'

tclean

Visualization Tools

- Visibilities: plotms, msview
- Images: viewer, imview
- Calibration tables: plotcal (or plotms)
- Any table values: browsetable
- Single dish: sdplot
- Plot anything: use python's matplotlib

Data Review: *plotms* (unix command line *casaplotms*)



File

Browse...

Selection

field

spw

timerange

uvrange

antenna

scan

observation

msselect

Averaging

□ Channel 0 channels

□ Time 0 seconds

□ Scan □ Field

□ All Baselines □ Per Antenna

□ All Spectral Windows

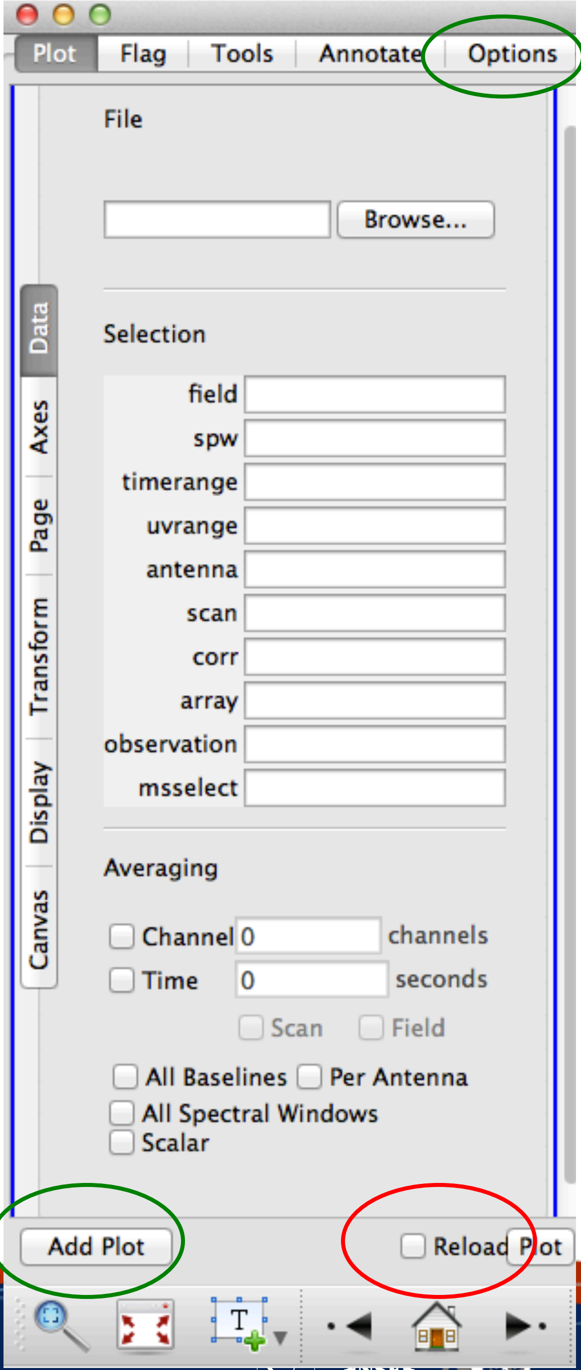
□ Scalar

Data Review: *plotms*

Control Panel: Data

Check the ‘Reload’ box if the MS has been modified through another task.

Use the ‘Options’ to divide the screen into multiple panels, and ‘Add plot’ to be able make plots of multiple data sets (or one data set but using different axes) onto the graphics panel.



☐ Channel 0 channels

☐ Time 0 seconds

☐ Scan ☐ Field

☐ All Baselines ☐ Per Antenna

☐ All Spectral Windows

☐ Scalar

☐ Reload

Data Review: *plotms*

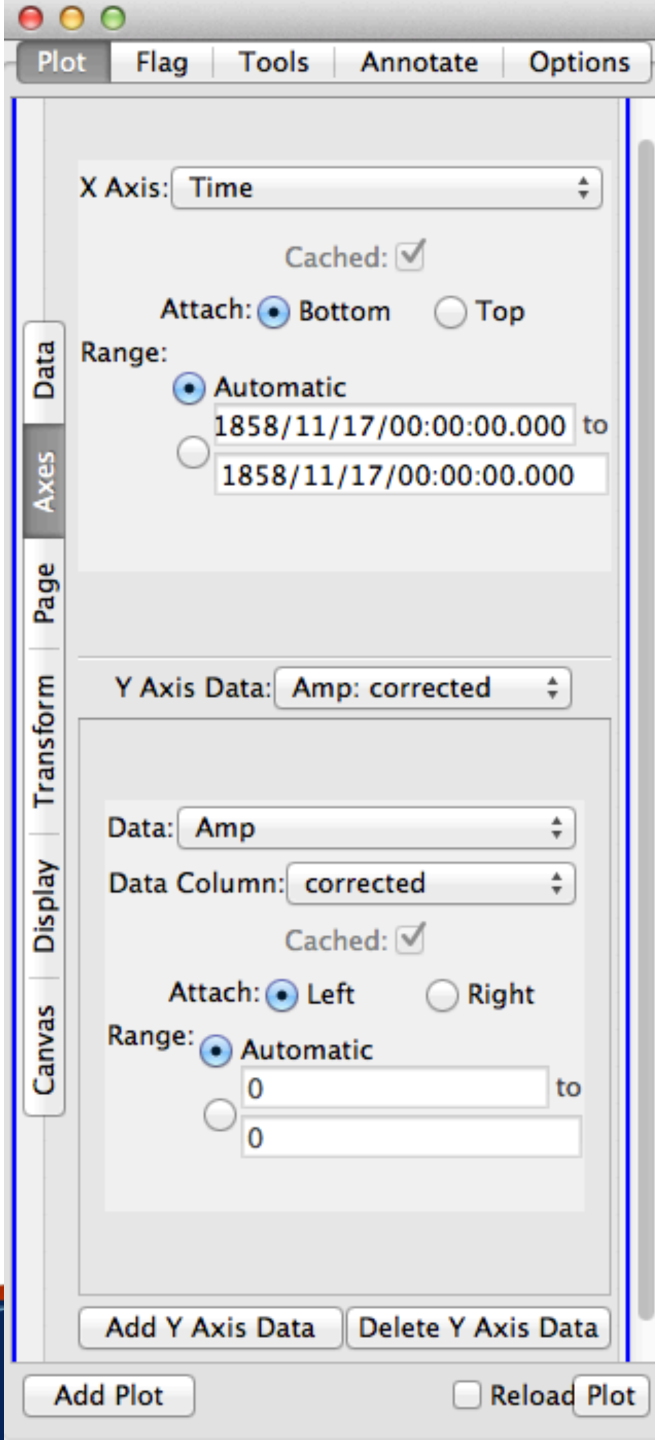
Axes

MS Ids and other meta info:

- 'scan'   (number)
- 'field' (index)
- 'time',
- 'interval'='timeint'='timeinterval'='time_interval'
- 'spw'   (index)
- 'chan'='channel'   (index)
- 'freq'='frequency' (GHz)
- 'vel'='velocity'   (km/s)
- 'corr'='correlation' (index)
- 'ant1'='antenna1'   (index)
- 'ant2'='antenna2'   (index)
- 'baseline' (a baseline index)
- 'row' (absoute row Id from the MS)

Visibility values, flags:

- 'amp'='amplitude'
- 'phase' (deg)
- 'real'
- 'imag'='imaginary'
- 'wt'='weight'
- 'flag'
- 'flagrow'



X Axis: Time

Cached: ☑

Attach: ● Bottom ○ Top

Range:
● Automatic
○ 1858/11/17/00:00:00.000 to 1858/11/17/00:00:00.000

Y Axis Data: Amp: corrected

Data: Amp

Data Column: corrected

Cached: ☑

Attach: ● Left ○ Right

Range:
● Automatic
○ 0 to 0

□ Reload

Data Review: *plotms*

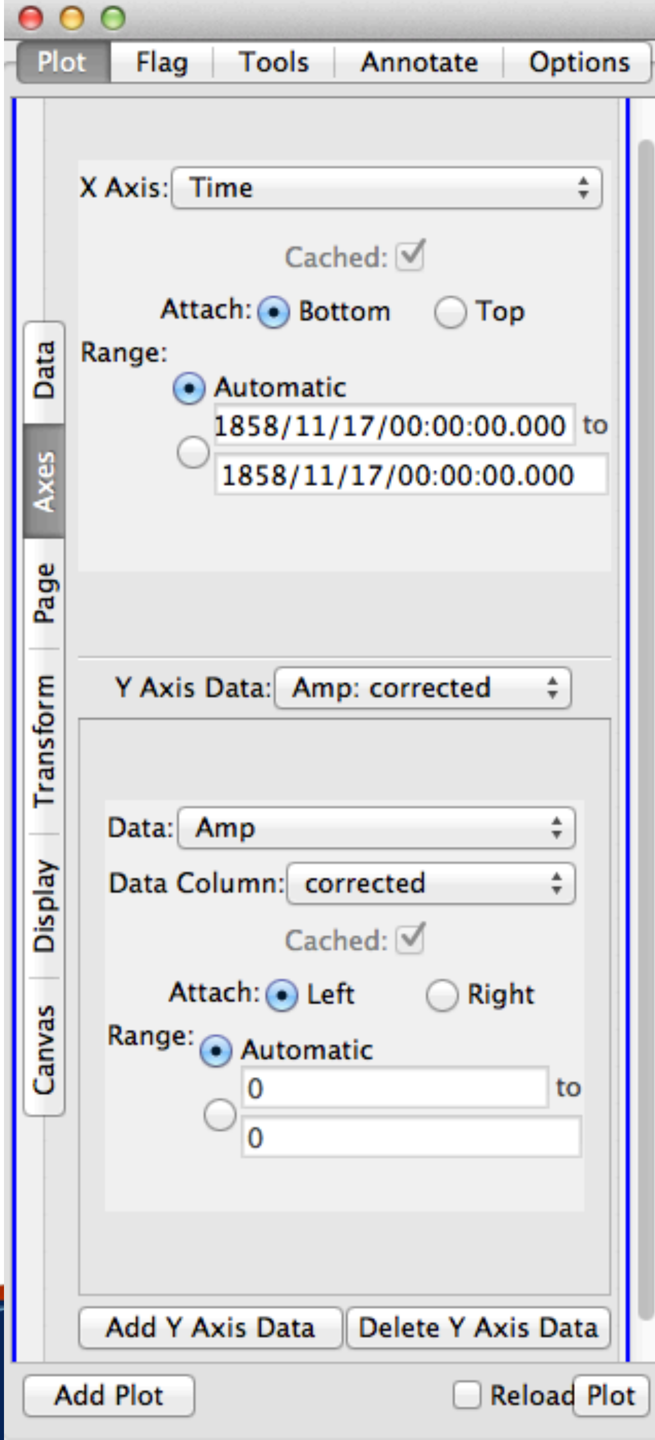
Axes

Observational geometry:

- 'uvdist' (meters)
- 'uvwave'='uvdistl'='uvdist_l' (wavelengths, per channel)
- 'u' (meters)
- 'v' (meters)
- 'w' (meters)
- 'azimuth' (at array reference; degrees)
- 'elevation' (at array reference; degrees)
- 'hourang'='hourangle' (at array reference; hours)
- 'parang'='parangle'='parallacticangle' (at array reference; degrees)

Antenna-based (only works vs. data Ids):

- 'ant'='antenna'
- 'ant-azimuth'
- 'ant-elevation'
- 'ant-parang'='ant-parangle'



X Axis: Time

Cached: ☑

Attach: ● Bottom ○ Top

Range: ● Automatic

○ 1858/11/17/00:00:00.000 to 1858/11/17/00:00:00.000

Y Axis Data: Amp: corrected

Data: Amp

Data Column: corrected

Cached: ☑

Attach: ● Left ○ Right

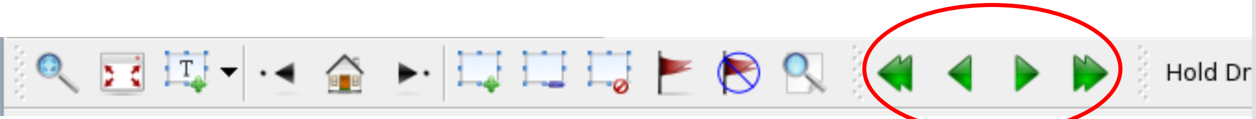
Range: ● Automatic

○ 0 to 0

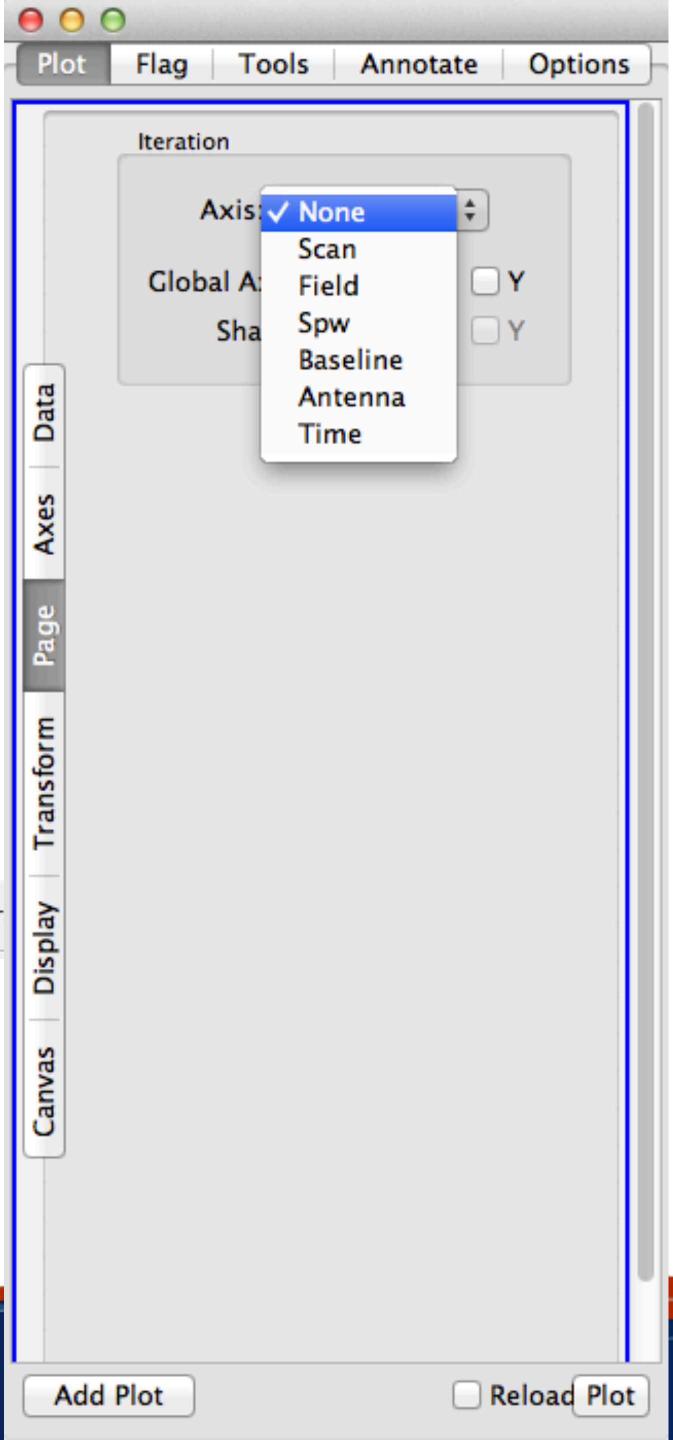
Data Review: *plotms*

Page: to iterate on

Scan
Field
Spw
Baseline
Antenna
Time



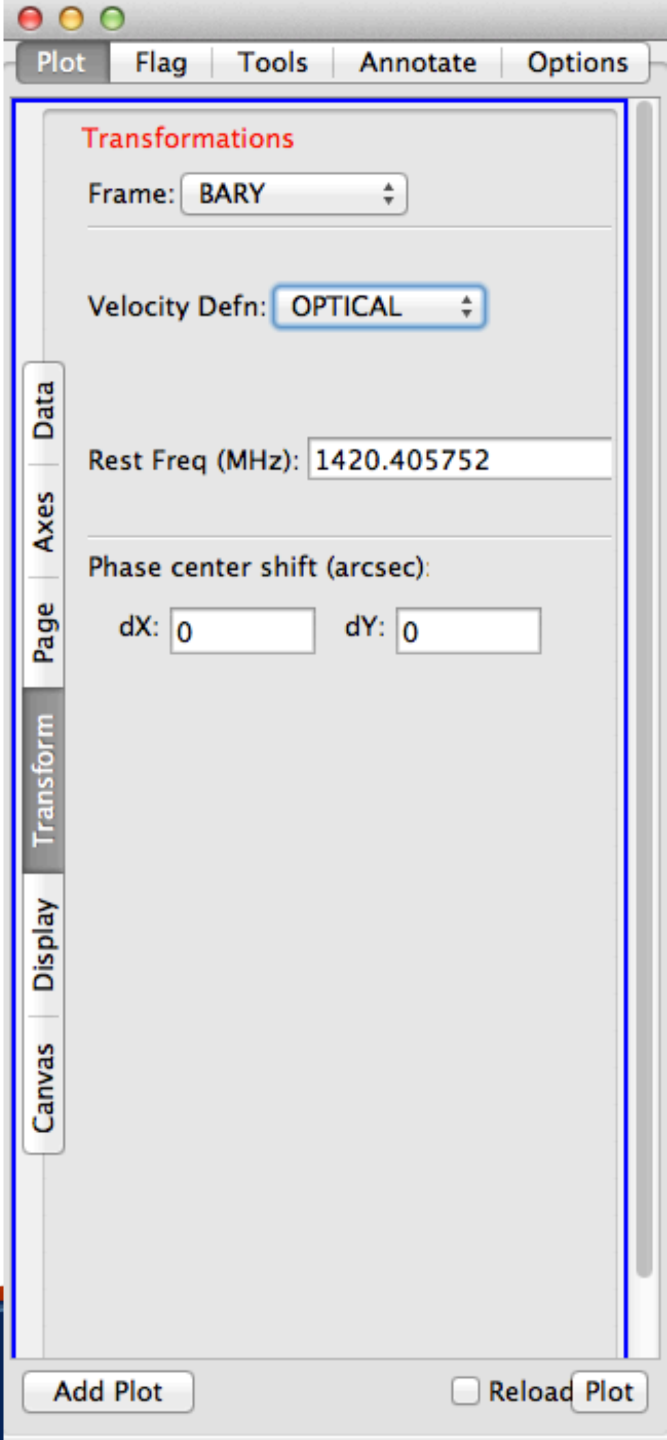
Tool panel



Data Review: *plotms*

Transformations

Frame: TOPO, GEO, BARY, LSRK, LSRD, etc..



Transformations

Frame: BARY

Velocity Defn: OPTICAL

Rest Freq (MHz): 1420.405752

Phase center shift (arcsec):

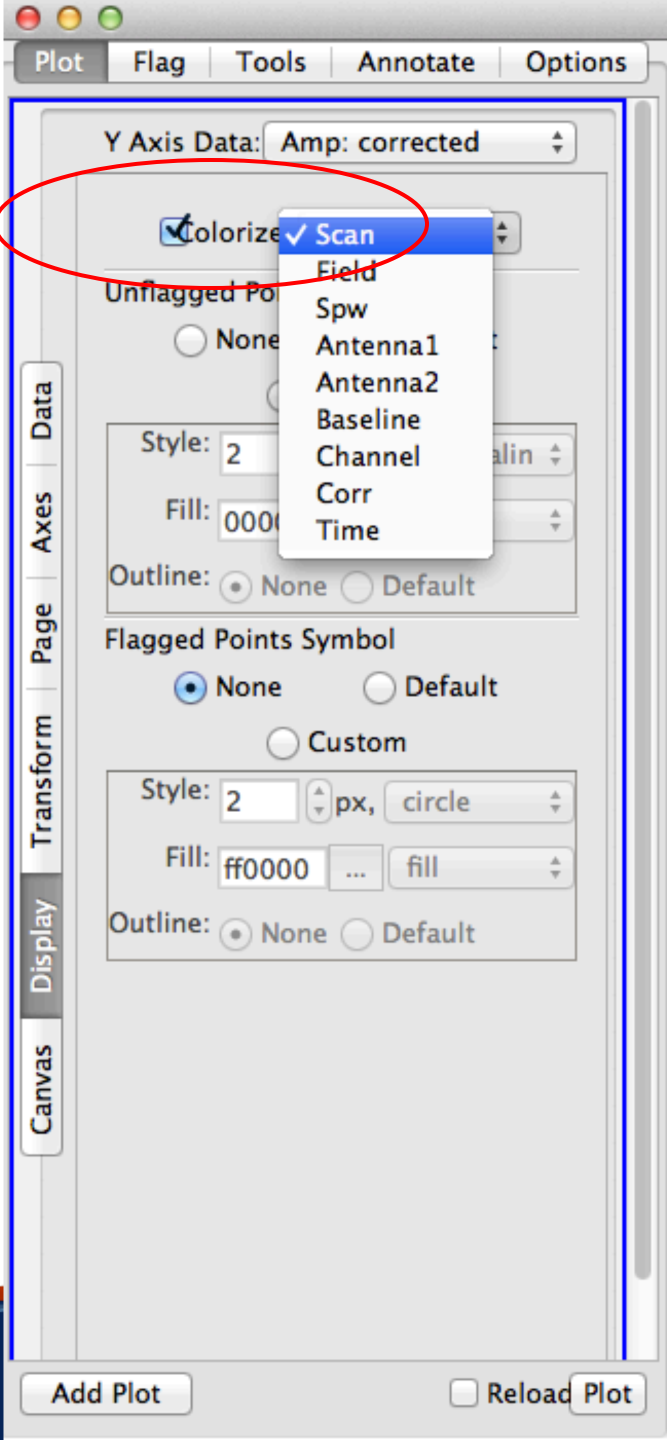
dX: 0 dY: 0

Data Review: *plotms*

Display

Colorize by:

- Scan
- Field
- Spw
- Antenna1
- Antenna2
- Baseline
- Channel
- Correlation
- Time



Y Axis Data: Amp: corrected

☑ Colorize ✓ Scan

Flagged Points Symbol

● None ○ Default ○ Custom

Style: 2 px, circle

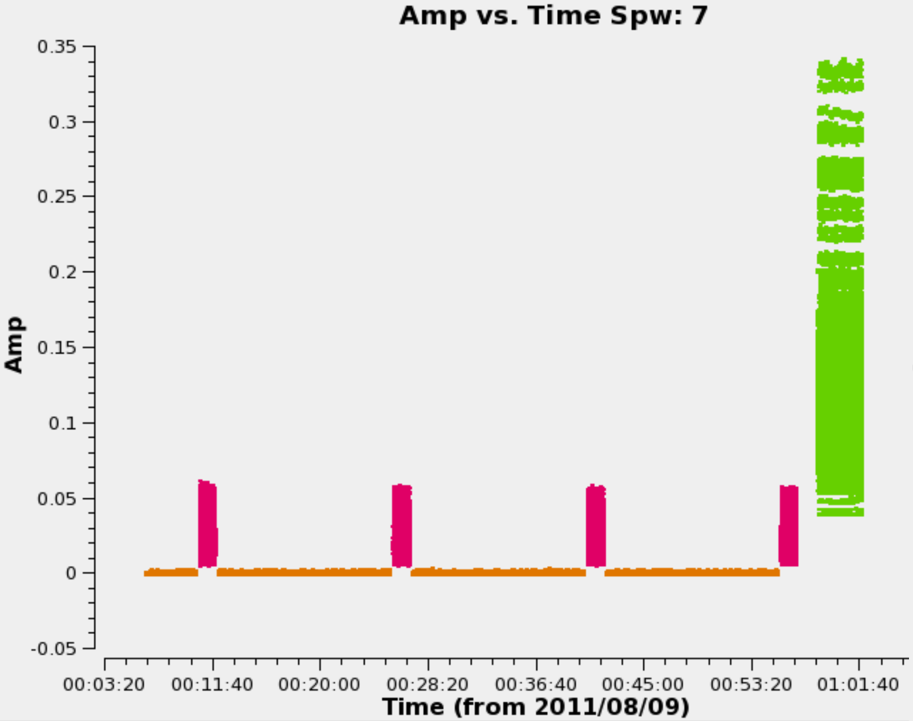
Fill: ff0000 ... fill

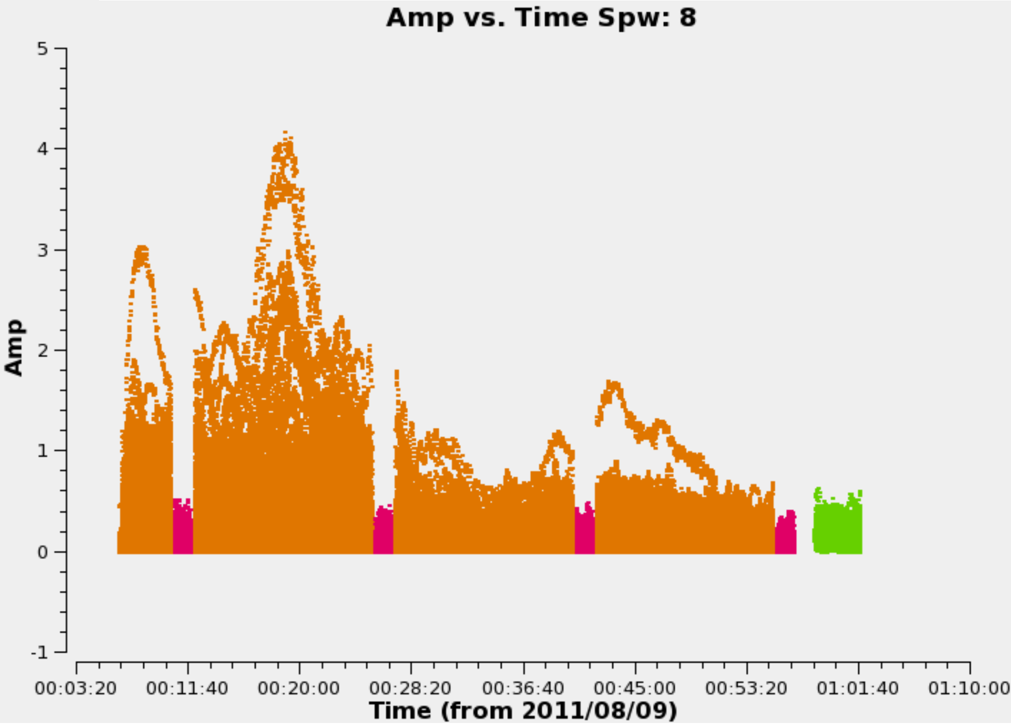
Outline: ● None ○ Default

Data Review: *plotms*

Example: x-axis: time, y-axis: amp

iter: spw (with all channels averaged)

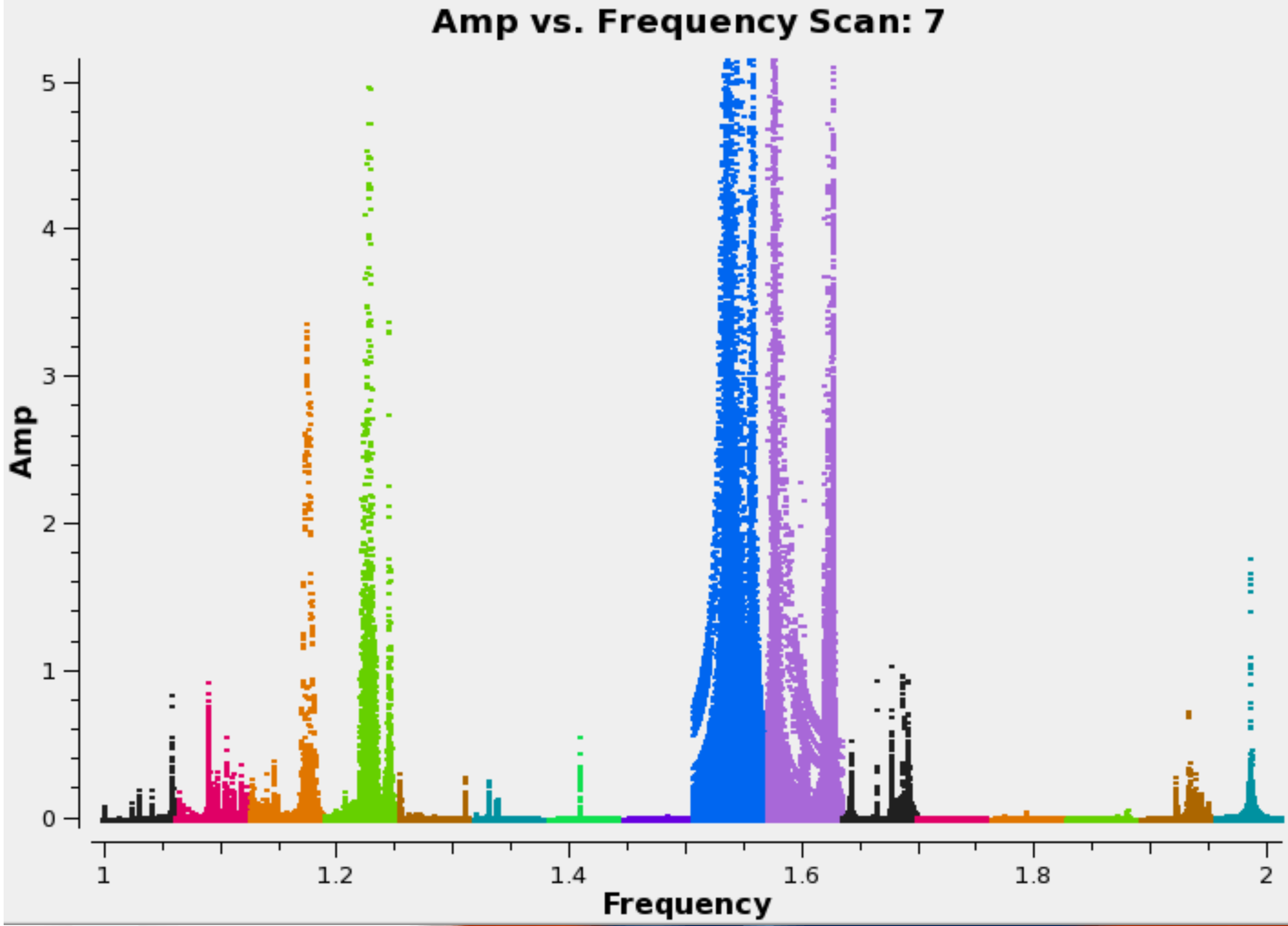




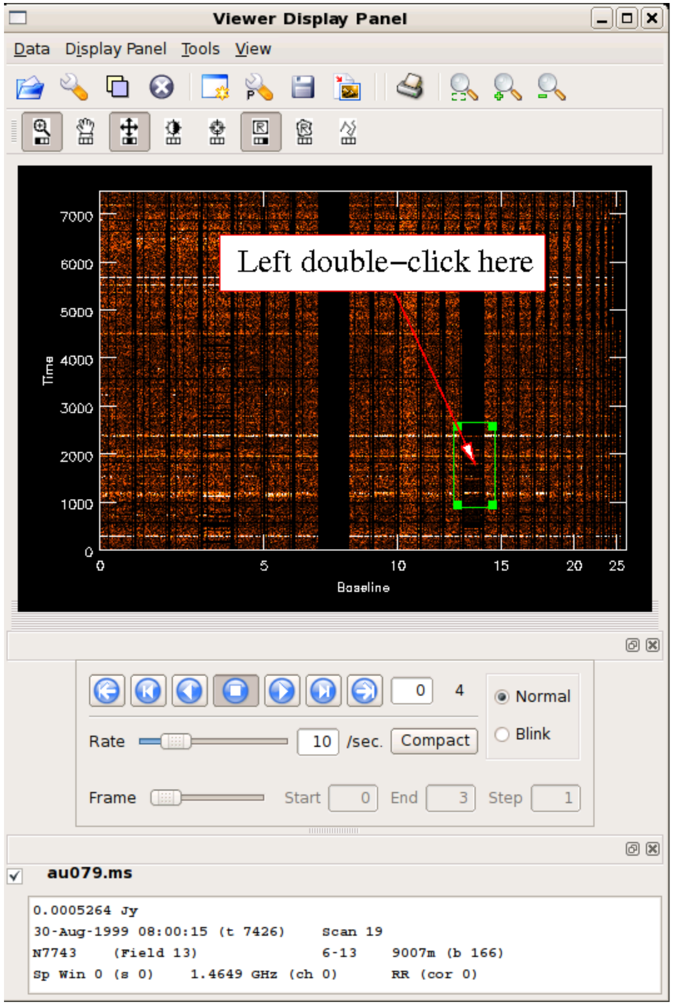
Data Review: *plotms*

Example: x-axis: frequency, y-axis: amp

iteration: scan



Data review: *msview*



Left double-click here

0 4

● Normal

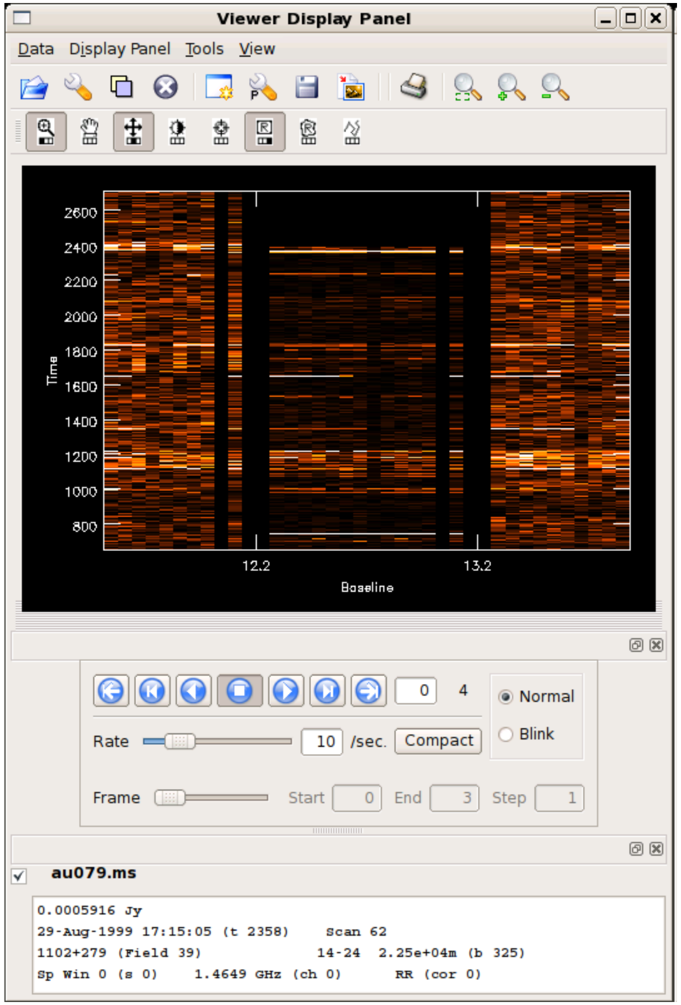
○ Blink

Rate 10 /sec.

Frame Start 0 End 3 Step 1

☑ au079.ms

```
0.0005264 Jy
30-Aug-1999 08:00:15 (t 7426)    Scan 19
N7743    (Field 13)              6-13    9007m (b 166)
Sp Win 0 (s 0)    1.4649 GHz (ch 0)      RR (cor 0)
```



0 4

● Normal

○ Blink

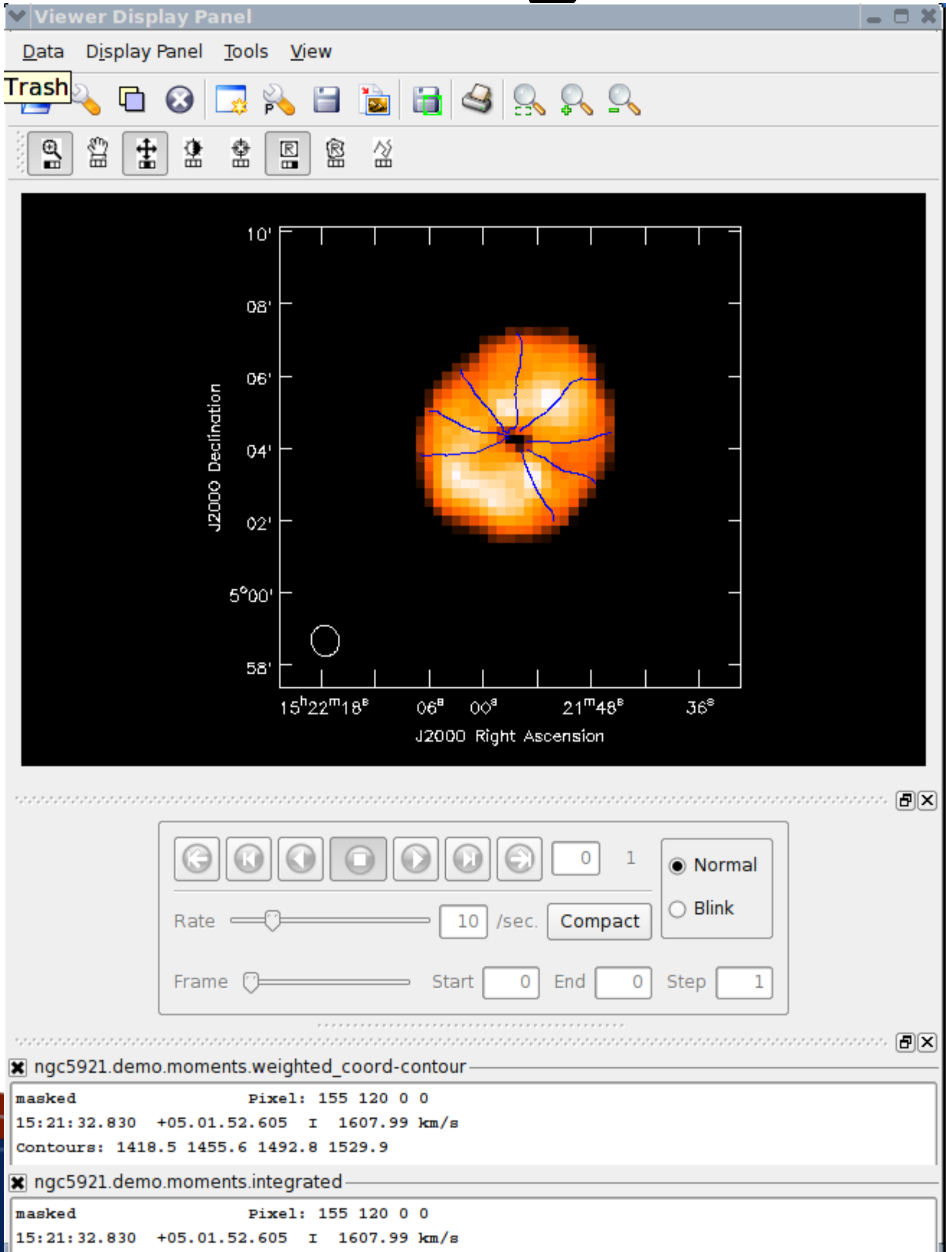
Rate 10 /sec.

Frame Start 0 End 3 Step 1

☑ au079.ms

```
0.0005916 Jy
29-Aug-1999 17:15:05 (t 2358)    Scan 62
1102+279 (Field 39)             14-24  2.25e+04m (b 325)
Sp Win 0 (s 0)    1.4649 GHz (ch 0)      RR (cor 0)
```

Image Viewer: *viewer*



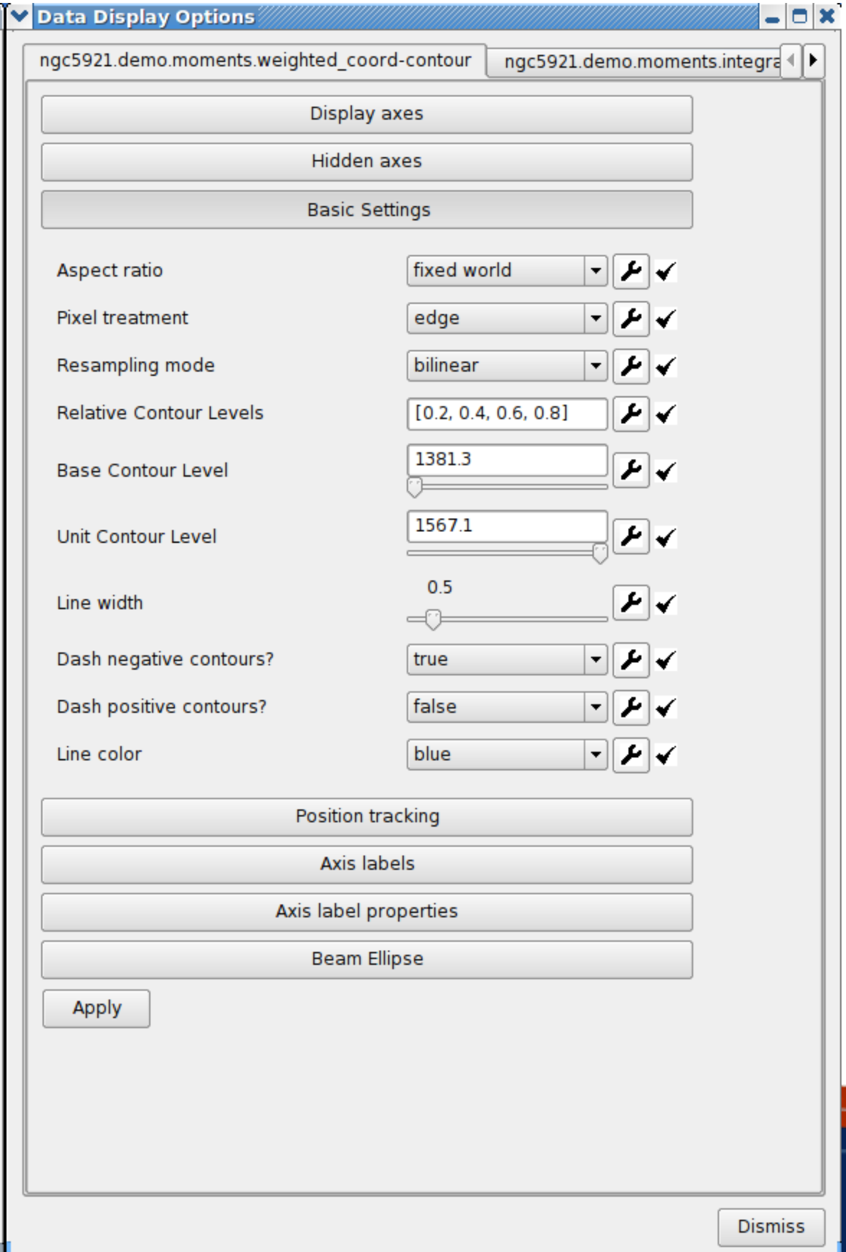
- Rate: 10 /sec.
- ● Normal ○ Blink
- Start: 0 End: 0 Step: 1

ngc5921.demo.moments.weighted_coord-contour

```
masked                    Pixel: 155 120 0 0
15:21:32.830  +05.01.52.605  I  1607.99 km/s
contours: 1418.5 1455.6 1492.8 1529.9
```

ngc5921.demo.moments.integrated

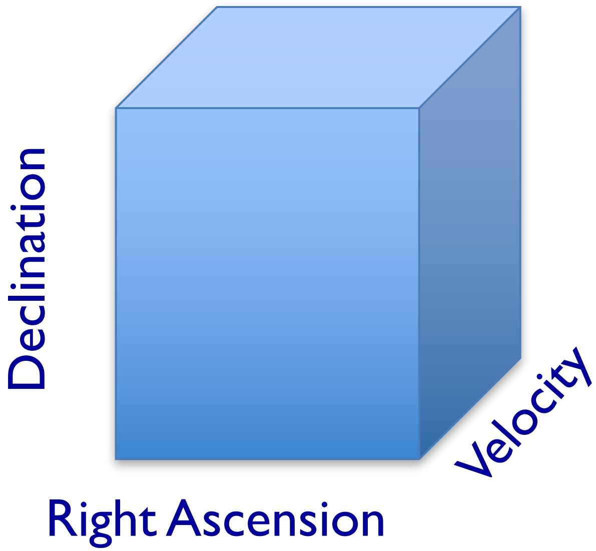
```
masked                    Pixel: 155 120 0 0
15:21:32.830  +05.01.52.605  I  1607.99 km/s
```

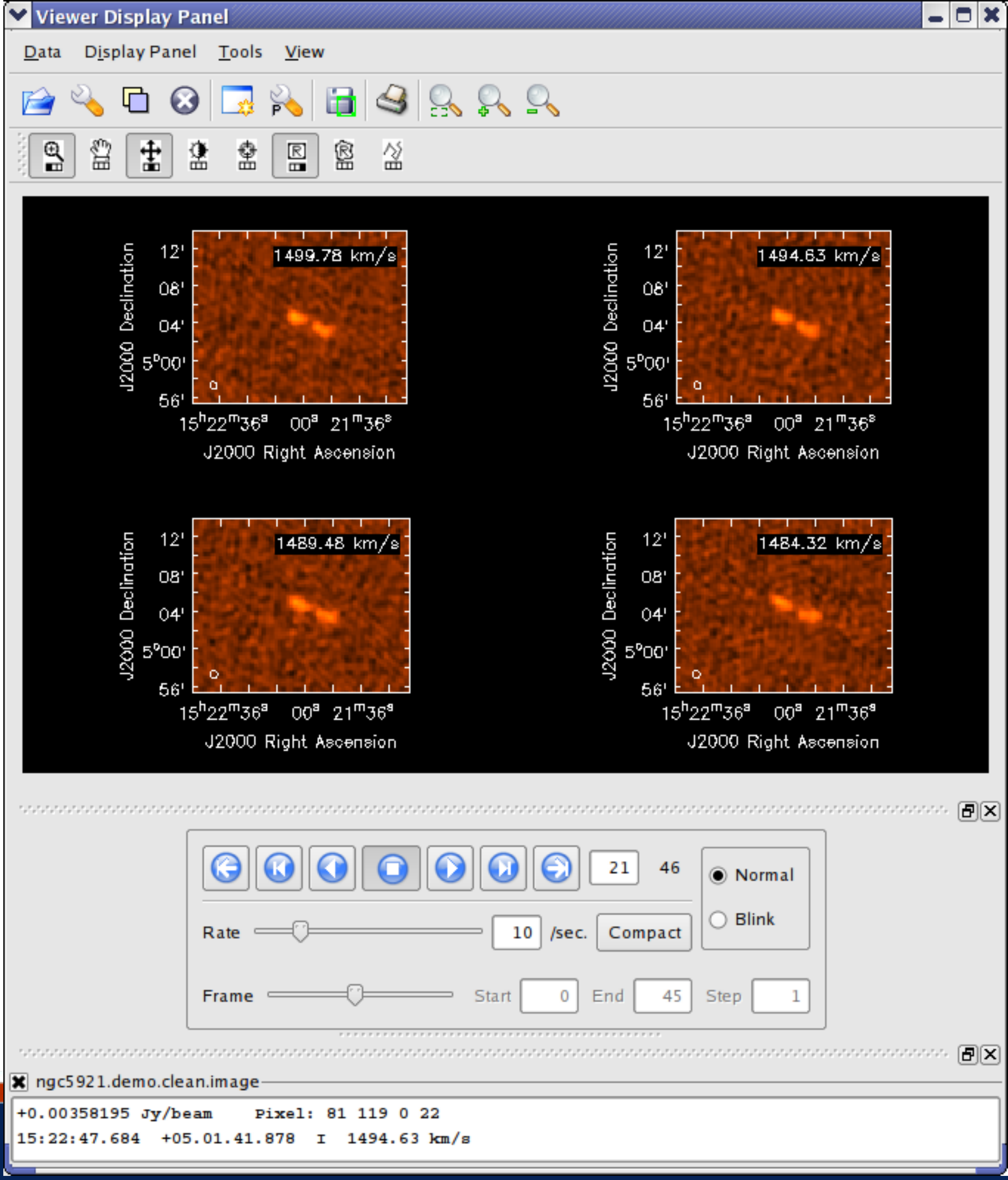


Aspect ratio	fixed world
Pixel treatment	edge
Resampling mode	bilinear
Relative Contour Levels	[0.2, 0.4, 0.6, 0.8]
Base Contour Level	1381.3
Unit Contour Level	1567.1
Line width	0.5
Dash negative contours?	true
Dash positive contours?	false
Line color	blue

Image Viewer

- Displaying cubes
- Movies
- Channel maps





21 46

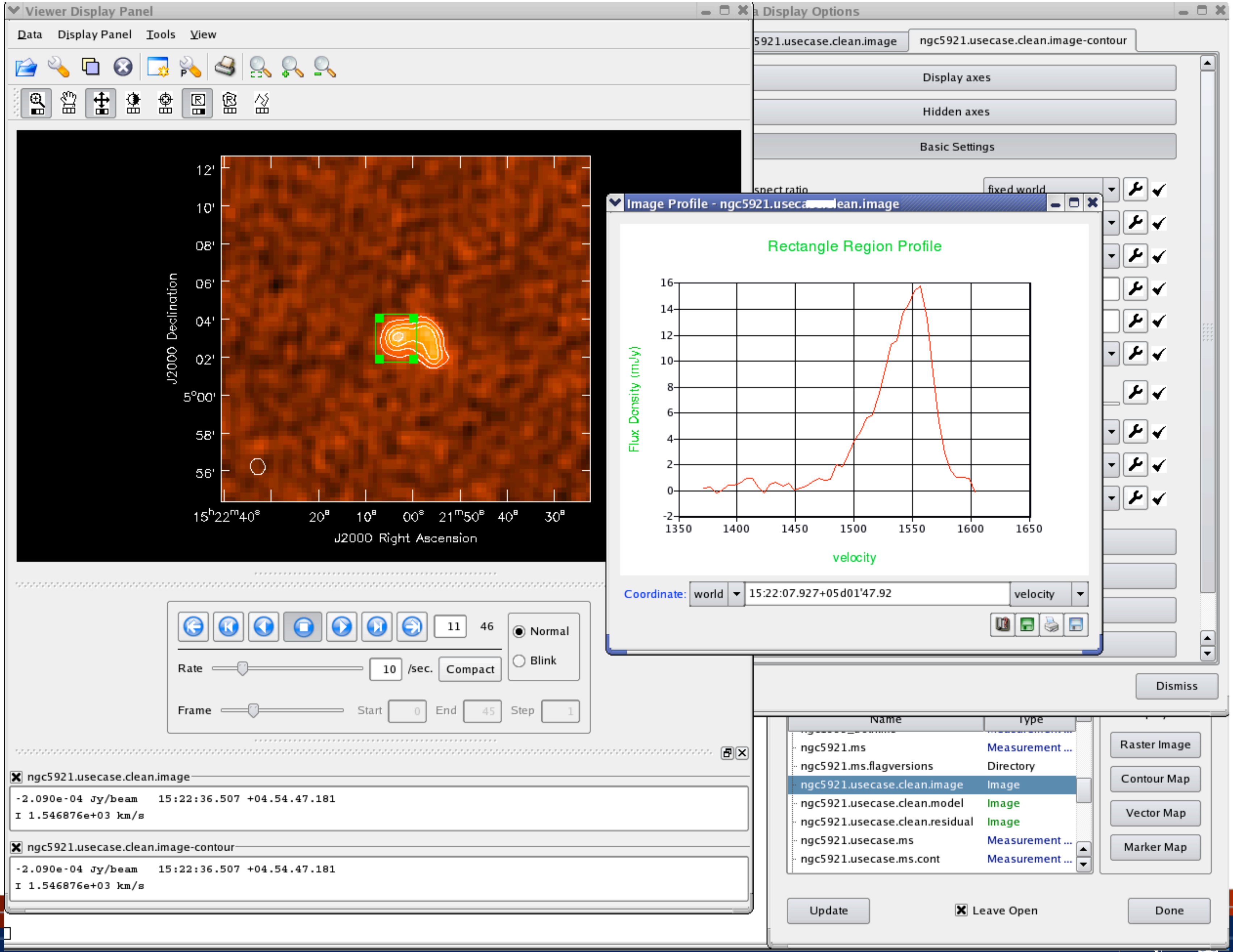
○ Normal ● selected: ● Normal ○ Blink

Rate 10 /sec.

Frame Start 0 End 45 Step 1

ngc5921.demo.clean.image

```
+0.00358195 Jy/beam     Pixel: 81 119 0 22
15:22:47.684  +05.01.41.878  I  1494.63 km/s
```



Coordinate: world 15:22:07.927+05d01'47.92 velocity

☒ ngc5921.usecase.clean.image

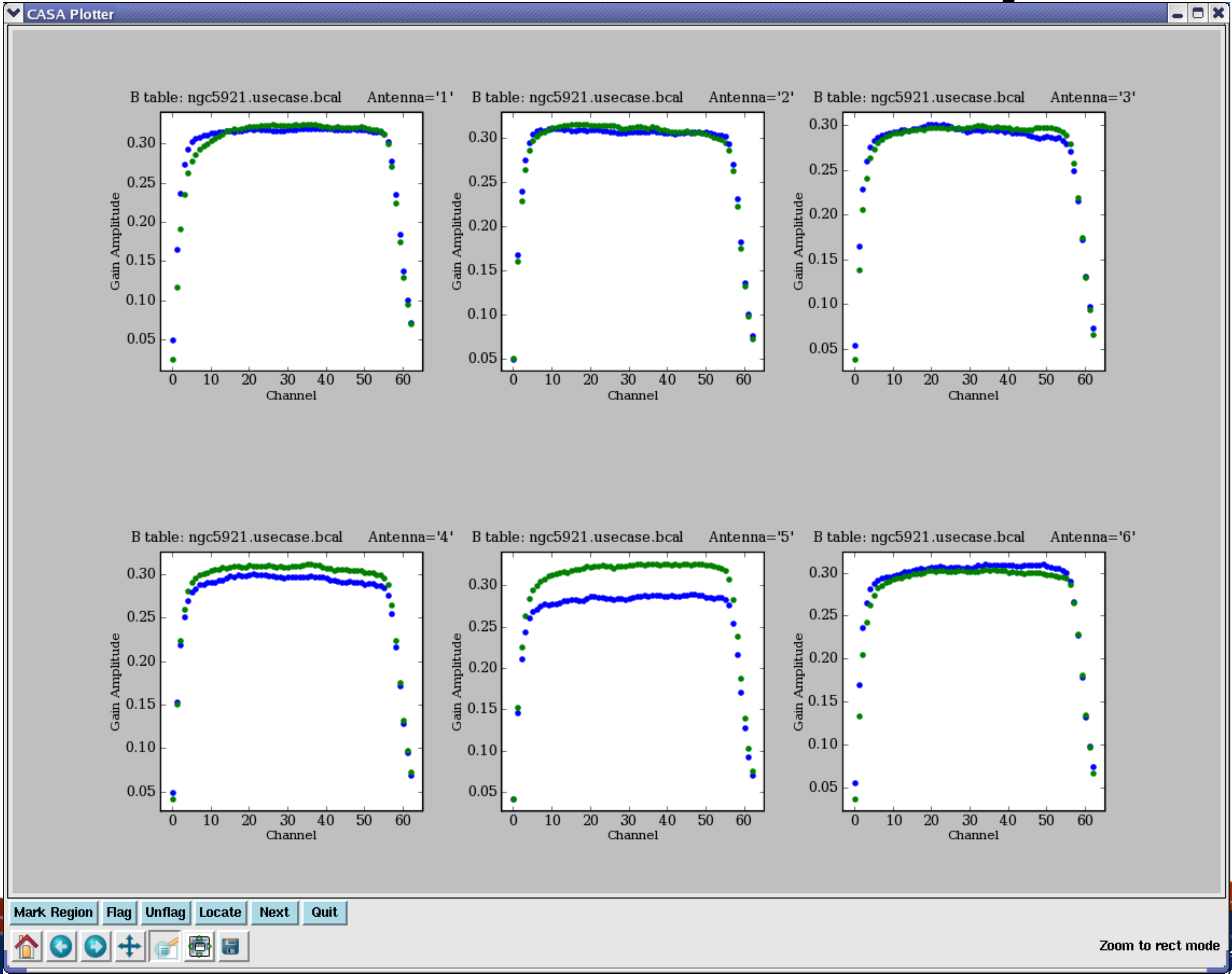
```
-2.090e-04 Jy/beam   15:22:36.507 +04.54.47.181
I 1.546876e+03 km/s
```

☒ ngc5921.usecase.clean.image-contour

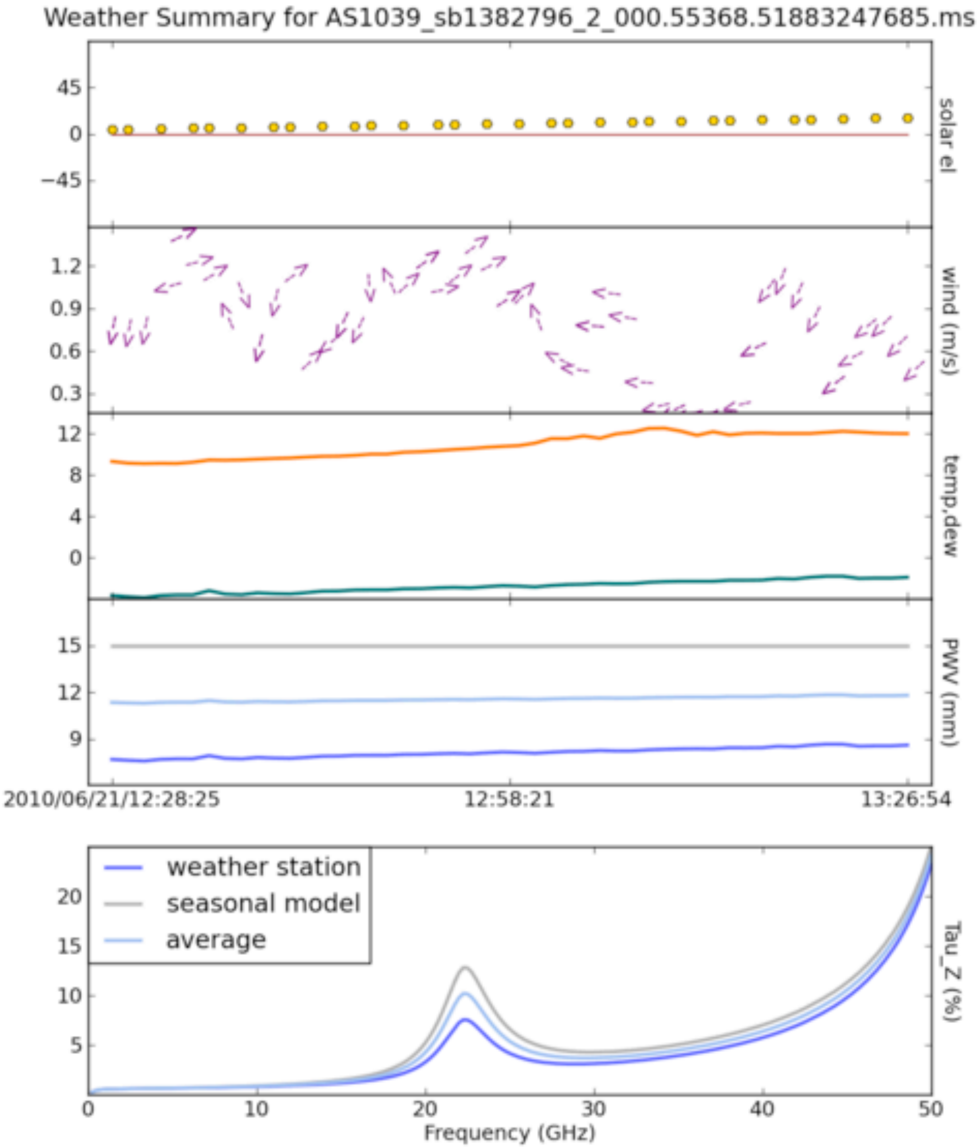
```
-2.090e-04 Jy/beam   15:22:36.507 +04.54.47.181
I 1.546876e+03 km/s
```

Name	Type
ngc5921.ms	Measurement ...
ngc5921.ms.flagversions	Directory
ngc5921.usecase.clean.image	Image
ngc5921.usecase.clean.model	Image
ngc5921.usecase.clean.residual	Image
ngc5921.usecase.ms	Measurement ...
ngc5921.usecase.ms.cont	Measurement ...

Review calibration tables: *plotcal*


CASA Plotter
B table: ngc5921.usecase.bcal Antenna='1'
B table: ngc5921.usecase.bcal Antenna='2'
B table: ngc5921.usecase.bcal Antenna='3'
B table: ngc5921.usecase.bcal Antenna='4'
B table: ngc5921.usecase.bcal Antenna='5'
B table: ngc5921.usecase.bcal Antenna='6'
Gain Amplitude
Channel
0.05
0.10
0.15
0.20
0.25
0.30
0
10
20
30
40
50
60
Mark Region
Flag
Unflag
Locate
Next
Quit
Zoom to rect mode

Anything - matplotlib



Buildmytasks

- Using Python, you can write your own scripts!
- Such scripts can be converted to tasks.
- If you wish, you can share them with the community (e.g., through NRAO).
- Contributed scripts are currently available at:

https://casaguides.nrao.edu/index.php/UST2

www.nrao.edu
science.nrao.edu
public.nrao.edu

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