Introduction to CASA

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CASA (Common Astronomy Software Applications)

- CASA is the offline data reduction package for ALMA and EVLA
- Beta Release Status:
  - in Beta Release since October 2007
  - Roughly biannual "patches"
  - register at http://my.nrao.edu
- Current Release: Beta Release Patch 2.4
- Next Release @Nov '09 (3.0)

Outline

- IPython & Python
- CASA help
- CASA task interface
- MS and data selection
- The Memory Sticks
- Documentation

CASA Interface

- IPython
  - shell access
  - autoparenthesis (autocall)
  - command history
  - session logging
    - ipython.log – ipython command history
    - casapy.log – casa messages
  - numbered input/output
  - history/searching
- Python
  - Cookbook Appendix D

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
- variables are global when using task interface!
- tasknames are objects (not variables)

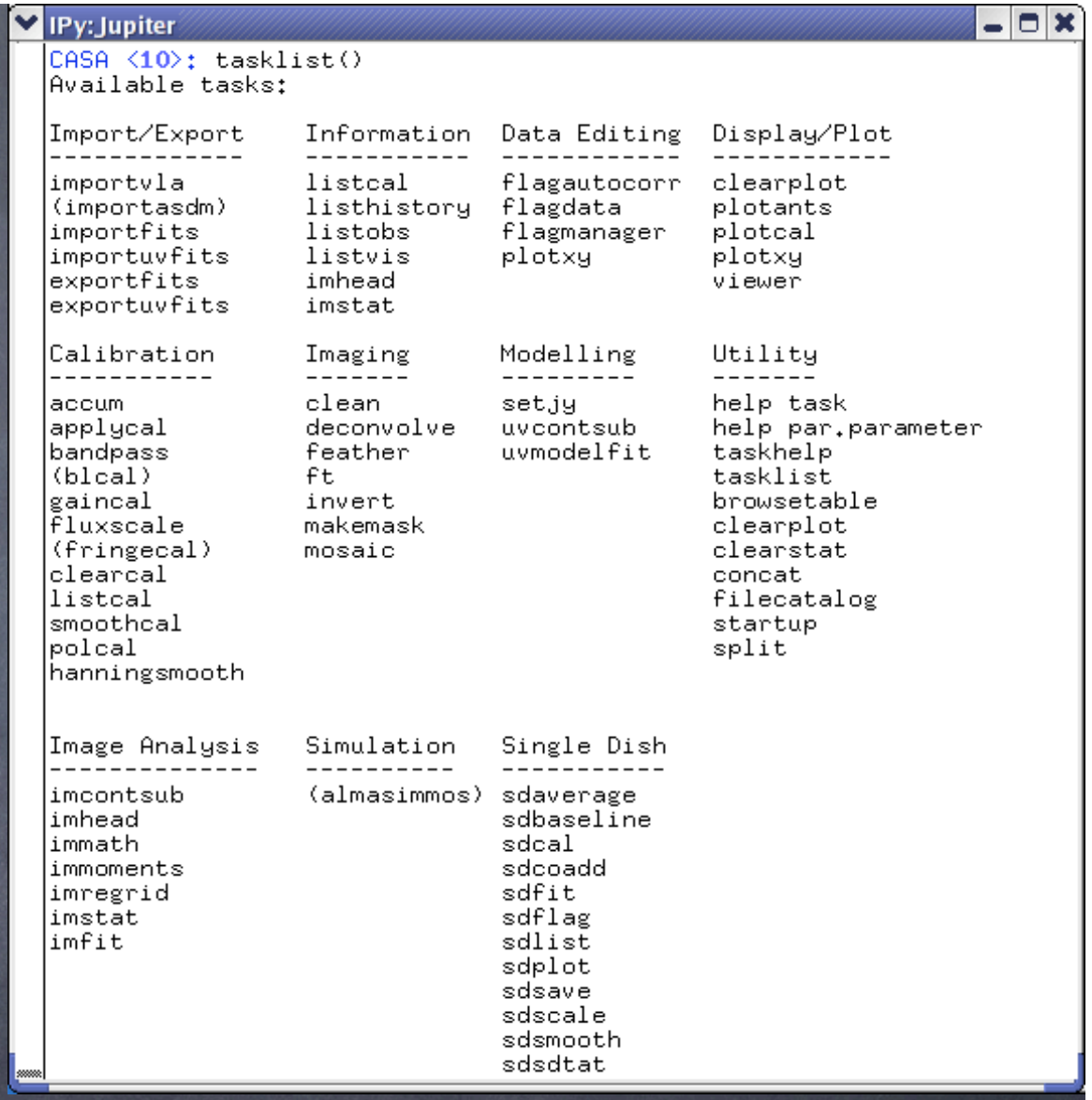
Tasks and tools in CASA

- Tasks - high-level functionality
  - 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

Key Tasks

- To see list of tasks after startup organized by type:

```
>tasklist
```



Task Execution

- two ways to invoke:
  - call from Python as functions with arguments
    - taskname(arg1=val1, arg2=val2, ...)
    - unspecified parameters will be defaulted (globals not used)
  - use standard tasking interface
    - use global variables for task parameters
  - see Chapter 1.3 in Cookbook

Task Interface

- standard tasking interface
  - use parameters set as global Python variables
    - set `<param> = <value>` (e.g. `vis = 'ngc5921.demo.ms'`)
  - parameter manipulation commands
    - using inp , default , saveinputs , tget
  - execute
    - `<taskname>` or `go` (e.g. `clean()`)
  - return values
    - some tasks return Python dictionaries, e.g. `myval=imval()`

Task Interface

- examine task parameters with inp :

IPy:Jupiter

```
CASA <1>: default('clean')

CASA <2>: inp('clean')
#  clean :: Deconvolve an image with selected algorithm
vis                 =            ''         #  name of input visibility file
imagename           =            ''         #  Pre-name of output images
field               =            ''         #  Field Name
spw                 =            ''         #  Spectral windows:channels: '' is all
selectdata          =         False         #  Other data selection parameters
mode                =         'mfs'         #  Type of selection (mfs, channel, velocity, frequency)
niter               =           500         #  Maximum number of iterations
gain                =           0.1         #  Loop gain for cleaning
threshold           =     '0.0mJy'          #  Flux level to stop cleaning.  Must include units
psfmode             =      'clark'          #  method of PSF calculation to use during minor cycles
imagermode          =            ''         #   Use csclean or mosaic.  If '', use psfmode
multiscale          =            []         #  set deconvolution scales (pixels), default: multiscale=[] (standard CLEAN)
interactive         =         False         #  use interactive clean (with GUI viewer)
mask                =            []         #  cleanbox(es), mask image(s), and/or region(s)  used in cleaning
imsize              = [256, 256]            #  x and y image size in pixels, symmetric for single value
cell                = ['1.0arcsec', '1.0arcsec'] #  x and y cell size, default unit arcsec
phasecenter         =            ''         #  Image phase center: position or field index
restfreq            =            ''         #  rest frequency to assign to image (see help)
stokes              =           'I'         #  Stokes params to image (eg I,IV, QU,IQUV)
weighting           =    'natural'          #  Weighting to apply to visibilities
uvtaper             =         False         #  Apply additional uv tapering of  visibilities.
modelimage          =            ''         #  Name of model image(s) to initialize cleaning
restoringbeam       =          ['']         #  Output Gaussian restoring beam for CLEAN image
pbcor               =         False         #  Output primary beam-corrected image
minpb               =           0.1         #  Minimum PB level to use
async               =         False         #  If true the taskname must be started using clean(...)

CASA <3>:
```

Expandable Parameters

- boldface parameter are expandable

IPy:Jupiter

```
CASA <3>: tget('clean')
Restored parameters from file clean.last

CASA <4>: inp()
#  clean :: Deconvolve an image with selected algorithm
vis                 = 'ngc5921.usecase.ms.contsub' #  name of input visibility file
imagename           = 'ngc5921.usecase.clean' #  Pre-name of output images
field               =         '0'           #  Field Name
spw                 =          ''           #  Spectral windows:channels: '' is all
selectdata          =       False           #  Other data selection parameters
mode                =   'channel'           #  Type of selection (mfs, channel, velocity, frequency)
     nchan          =          46           #  Number of channels (planes) in output image
     start          =           5           #  first input channel to use
     width          =           1           #  Number of input channels to average

niter               =        6000           #  Maximum number of iterations
gain                =         0.1           #  Loop gain for cleaning
threshold           =         8.0           #  Flux level to stop cleaning,  Must include units
psfmode             =     'clark'           #  method of PSF calculation to use during minor cycles
imagermode          =          ''           #   Use csclean or mosaic,  If '', use psfmode
multiscale          =          []           #  set deconvolution scales (pixels), default: multiscale=[] (standard CLEAN)
interactive         =       False           #  use interactive clean (with GUI viewer)
mask                = [108, 108, 148, 148] #  cleanbox(es), mask image(s), and/or region(s)  used in cleaning
imsize              = [256, 256]            #  x and y image size in pixels, symmetric for single value
cell                = [15.0, 15.0]          #  x and y cell size, default unit arcsec
phasecenter         =          ''           #  Image phase center: position or field index
restfreq            =          ''           #  rest frequency to assign to image (see help)
stokes              =         'I'           #  Stokes params to image (eg I,IV, QU,IQUV)
weighting           =    'briggs'           #  Weighting to apply to visibilities
     robust         =         0.5           #  Briggs robustness parameter
     npixels        =           0           #  number of pixels to determine uv-cell size 0=> field of view

uvtaper             =       False           #  Apply additional uv tapering of  visibilities.
modelimage          =          ''           #  Name of model image(s) to initialize cleaning
```

Parameter Checking

- sanity checks of parameters in inp :

IPy:Jupiter

```
CASA <5>: psfmode='hogwarts'

CASA <6>: inp()
#  clean :: Deconvolve an image with selecte
vis                 = 'ngc5921.usecase.ms.cc                bility file
imagename           = 'ngc5921.usecase.clear                es
field               =        '0'           #  F
spw                 =         ''           #  S                is all
selectdata          =      False           #  C                rs
mode                =  'channel'           #  T                el, velocity, frequency)
     nchan          =         46           #  Number of channels (planes) in output image
     start          =          5           #  First input channel to use
     width          =          1           #  Number of input channels to average

niter               =       6000           #  Maximum number of iterations
gain                =        0.1           #  Loop gain for cleaning
threshold           =        8.0           #  Flux level to stop cleaning.  Must include units
psfmode             = 'hogwarts'           #  method of PSF calculation to use during minor cycles
imagermode          =         ''           #   Use csclean or mosaic.  If '', use psfmode
multiscale          =         []           #  set deconvolution scales (pixels), default: multiscale=[] (standard CLEAN)
interactive         =      False           #  use interactive clean (with GUI viewer)
mask                = [108, 108, 148, 148] #  cleanbox(es), mask image(s), and/or region(s)  used in cleaning
imsize              = [256, 256]           #  x and y image size in pixels, symmetric for single value
cell                = [15.0, 15.0]         #  x and y cell size, default unit arcsec
phasecenter         =         ''           #  Image phase center: position or field index
restfreq            =         ''           #  rest frequency to assign to image (see help)
stokes              =        'I'           #  Stokes params to image (eg I,IV, QU,IQUV)
weighting           =  'briggs'            #  Weighting to apply to visibilities
     robust         =        0.5           #  Briggs robustness parameter
     npixels        =          0           #  number of pixels to determine uv-cell size 0=> field of view

uvtaper             =      False           #  Apply additional uv tapering of  visibilities.
modelimage          =         ''           #  Name of model image(s) to initialize cleaning
restoringbeam       =       ['']           #  Output Gaussian restoring beam for CLEAN image
```

erroneous values in red

Help on Tasks

- In-line help:

>help 'clean' OR >pdoc clean

IPy:Jupiter

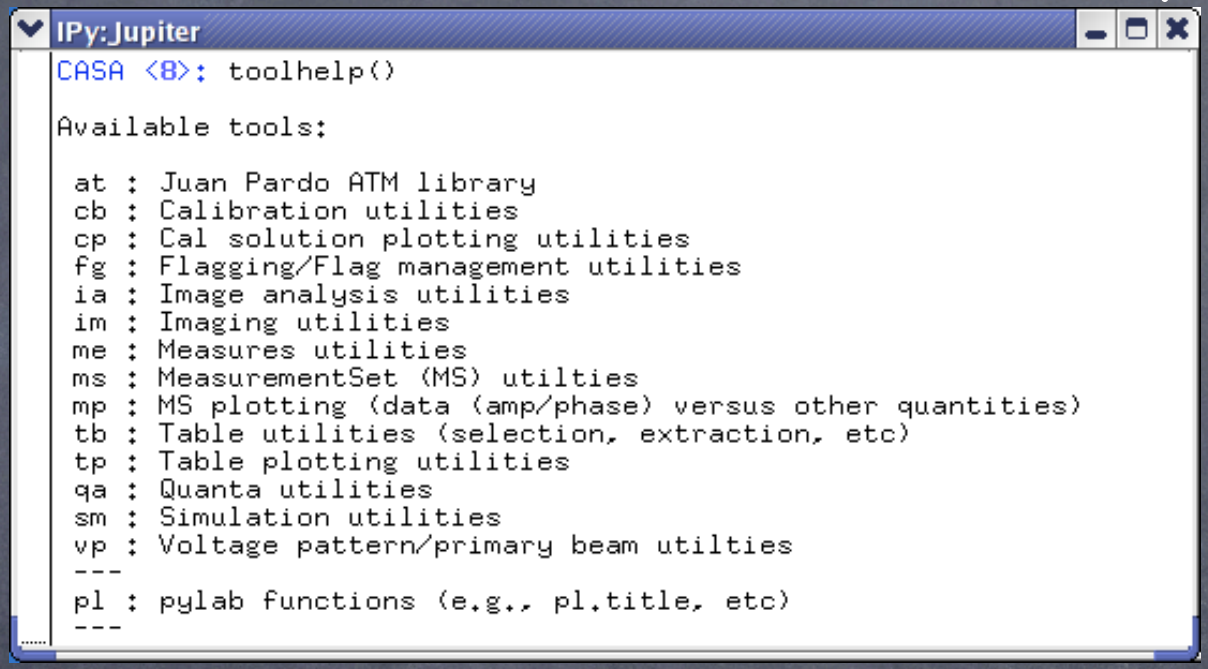
```
CASA <7>: help('clean')
Help on module clean:

NAME
    clean

FILE
    /usr/lib/casapy/20.0.5444test-001/lib/python2.5/clean.py

DESCRIPTION
    # This file was generated using xslt from its XML file
    #
    # Copyright 2007, Associated Universities Inc., Washington DC
    #

FUNCTIONS
    clean_imp(vis=None, imagename=None, field=None, spw=None, selectdata=
 gain=None, threshold=None, psfmode=None, imagermode=None, ftmachine=None
one, mask=None, nchan=None, start=None, width=None, imsize=None, cell=Non
er=None, outertaper=None, innertaper=None, modelimage=None, restoringbeam
r=None, cyclespeedup=None, async=None)
        Deconvolve an image with selected algorithm

             The main clean deconvolution task.  It contains many functio

              1)  Make 'dirty' image and 'dirty' beam (psf)
              2)  Multi-frequency-continuum images or spectral channel im
              3)  Full Stokes imaging
              4)  Mosaicking of several pointings
              5)  Multi-scale cleaning
              6)  Interactive clean boxing
              7)  Initial starting model


             vis -- Name of input visibility file
                     default: none; example: vis='ngc5921.ms'
             imagename -- Pre-name of output images:
                     default: none; example: imagename='m2'
                     output images are:
                       m2.image: cleaned and restored image
                              With or without primary beam correction
                       m2.psf: point-spread function (dirty beam)
                       m2.flux:  relative sky sensitivity over field
                       m2.model: image of clean components
```

Tools in CASA

- CASA Toolkit underneath tasks
  - core AIPS++ code (mostly in C++)
- tools are functions
  - 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

- list of default tools from toolhelp :



- tools described in the CASA User Reference Manual:
  - http://casa.nrao.edu/docs/casaref/CasaRef.html

The Measurement Set

- the MS is a directory on disk
  - the MAIN table in `table.*` files
  - also contains sub-tables
    - e.g. FIELD, SOURCE, ANTENNA, etc.
  - sub-tables are sub-directories
  - to copy must `cp -rf` to get contents
  - Best to remove ms with `rmtables('filename')`
    - WARNING: moving a MS can break cal-table dependencies

Example MS

- Example: `ls ngc5921.usecase.ms`

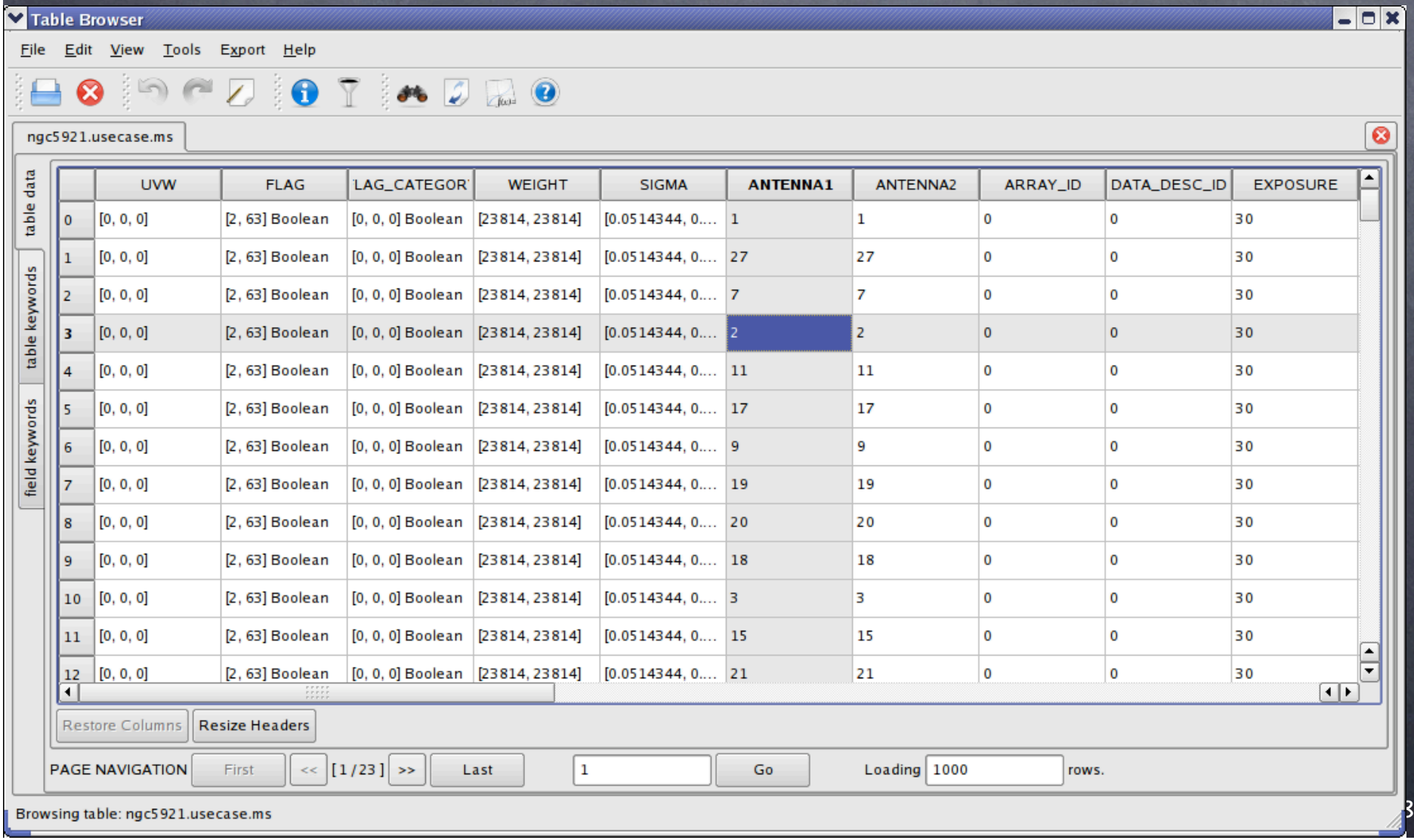
```
smyers@olorin ~/CASA/Test $ ls ngc5921.usecase.ms
ANTENNA                 POLARIZATION            table.f1                table.f3_TSM1           table.f8
DATA_DESCRIPTION        PROCESSOR               table.f10               table.f4                table.f8_TSM1
FEED                    SORTED_TABLE            table.f10_TSM1          table.f5                table.f9
FIELD                   SOURCE                  table.f11               table.f5_TSM1           table.f9_TSM1
FLAG_CMD                SPECTRAL_WINDOW         table.f11_TSM1          table.f6                table.info
HISTORY                 STATE                   table.f2                table.f6_TSM0           table.lock
OBSERVATION             table.dat               table.f2_TSM1           table.f7
POINTING                table.f0                table.f3                table.f7_TSM1
```

- `ls ngc5921.usecase.ms/FIELD`

```
smyers@olorin ~/CASA/Test $ ls ngc5921.usecase.ms/FIELD
table.dat       table.f0        table.f0i       table.info      table.lock
```

MAIN Table Contents

- Example using task browsetable:



	UVW	FLAG	LAG_CATEGOR	WEIGHT	SIGMA	ANTENNA1	ANTENNA2	ARRAY_ID	DATA_DESC_ID	EXPOSURE
0	[0, 0, 0]	[2, 63] Boolean	[0, 0, 0] Boolean	[23814, 23814]	[0.0514344, 0....	1	1	0	0	30
1	[0, 0, 0]	[2, 63] Boolean	[0, 0, 0] Boolean	[23814, 23814]	[0.0514344, 0....	27	27	0	0	30
2	[0, 0, 0]	[2, 63] Boolean	[0, 0, 0] Boolean	[23814, 23814]	[0.0514344, 0....	7	7	0	0	30
3	[0, 0, 0]	[2, 63] Boolean	[0, 0, 0] Boolean	[23814, 23814]	[0.0514344, 0....	2	2	0	0	30
4	[0, 0, 0]	[2, 63] Boolean	[0, 0, 0] Boolean	[23814, 23814]	[0.0514344, 0....	11	11	0	0	30
5	[0, 0, 0]	[2, 63] Boolean	[0, 0, 0] Boolean	[23814, 23814]	[0.0514344, 0....	17	17	0	0	30
6	[0, 0, 0]	[2, 63] Boolean	[0, 0, 0] Boolean	[23814, 23814]	[0.0514344, 0....	9	9	0	0	30
7	[0, 0, 0]	[2, 63] Boolean	[0, 0, 0] Boolean	[23814, 23814]	[0.0514344, 0....	19	19	0	0	30
8	[0, 0, 0]	[2, 63] Boolean	[0, 0, 0] Boolean	[23814, 23814]	[0.0514344, 0....	20	20	0	0	30
9	[0, 0, 0]	[2, 63] Boolean	[0, 0, 0] Boolean	[23814, 23814]	[0.0514344, 0....	18	18	0	0	30
10	[0, 0, 0]	[2, 63] Boolean	[0, 0, 0] Boolean	[23814, 23814]	[0.0514344, 0....	3	3	0	0	30
11	[0, 0, 0]	[2, 63] Boolean	[0, 0, 0] Boolean	[23814, 23814]	[0.0514344, 0....	15	15	0	0	30
12	[0, 0, 0]	[2, 63] Boolean	[0, 0, 0] Boolean	[23814, 23814]	[0.0514344, 0....	21	21	0	0	30

Data Selection Example

- standard selection parameters
  - e.g. for task gaincal:

```
CASA <14>: inp
---------> inp()
#  gaincal :: Determine temporal gains from calibrator observations:

vis                 = 'ngc5921.ms'      #   Name of input visibility file
caltable            = 'ngc5921.gcal'    #   Name of output calibration table
field               =      '0,1'        #   field names or index of calibrators ''==>all
spw                 =    '0:2~56'       #   spectral window:channels: ''==>all
selectdata          =       True        #   Other data selection parameters
     timerange      =         ''        #   time range: ''==>all
     uvrange        =         ''        #   uv range''=all
     antenna        =         ''        #   antenna/baselines: ''==>all
     scan           =         ''        #   scan numbers
     msselect       =         ''        #   Optional data selection (Specialized. but see help)
```

  - field and spw common standard selections
  - expandable selectdata with other selections as sub-parameters

Data Selection Syntax

- see Chapter 2.5 of Cookbook
  - 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 specwindow ID plus channels
    - use ':' as separator of spw from optional channelization
    - use '^' as separator of channels from step/width
    - example: spw = '0~2' ; spw = '1:10~30' ; spw = '2~5:5~54^5'

Selection Syntax

- see Chapter 2.5 of Cookbook
  - antenna - string with antenna name or ID
    - first check for name, then ID (beware VLA name 1-27, ID 0-26)
    - example: antenna = '1~5,11' ; antenna = 'VA*'
  - timerange - string with date/time range
    - specify 'T0~T1' , missing parts of T1 default to T0, can give 'T0+dT'
    - example: timerange = '2007/10/16/01:00:00~06:30:00'

The Memory Sticks etc.

- Contents:
  - "Install_README" - installation instructions
  - "installation" - directory contains 32-bit linux and intel mac files. Please see me if you need 64-bit linux. Please install before Wed.
  - "casa_scripts_and_data.tar" copy this to your hard drive before Wed. Note a copy of the casa cookbook is included in this directory. A slightly newer version is available at http://www.aoc.nrao.edu/~smyers/naug/doc/cookbook/casa_cookbook.pdf
- Additional CASA Scripts & Data Page
  - http://casa.nrao.edu/casatraining.shtml

Getting User Support

- First stop:
  - CASA Home: http://casa.nrao.edu
  - Cookbook, and "help" within CASA
- CASA Helpdesk & Support
  - "Helpdesk" at http://my.nrao.edu (will migrate to more user friendly helpdesk in future)
  - You will need to register first
    - Submit questions, suggestions, bugs

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/