



Simulating ALMA observations

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Outline

The simulators and cycle 5 proposals

Available simulators

Overview of the CASA simulator

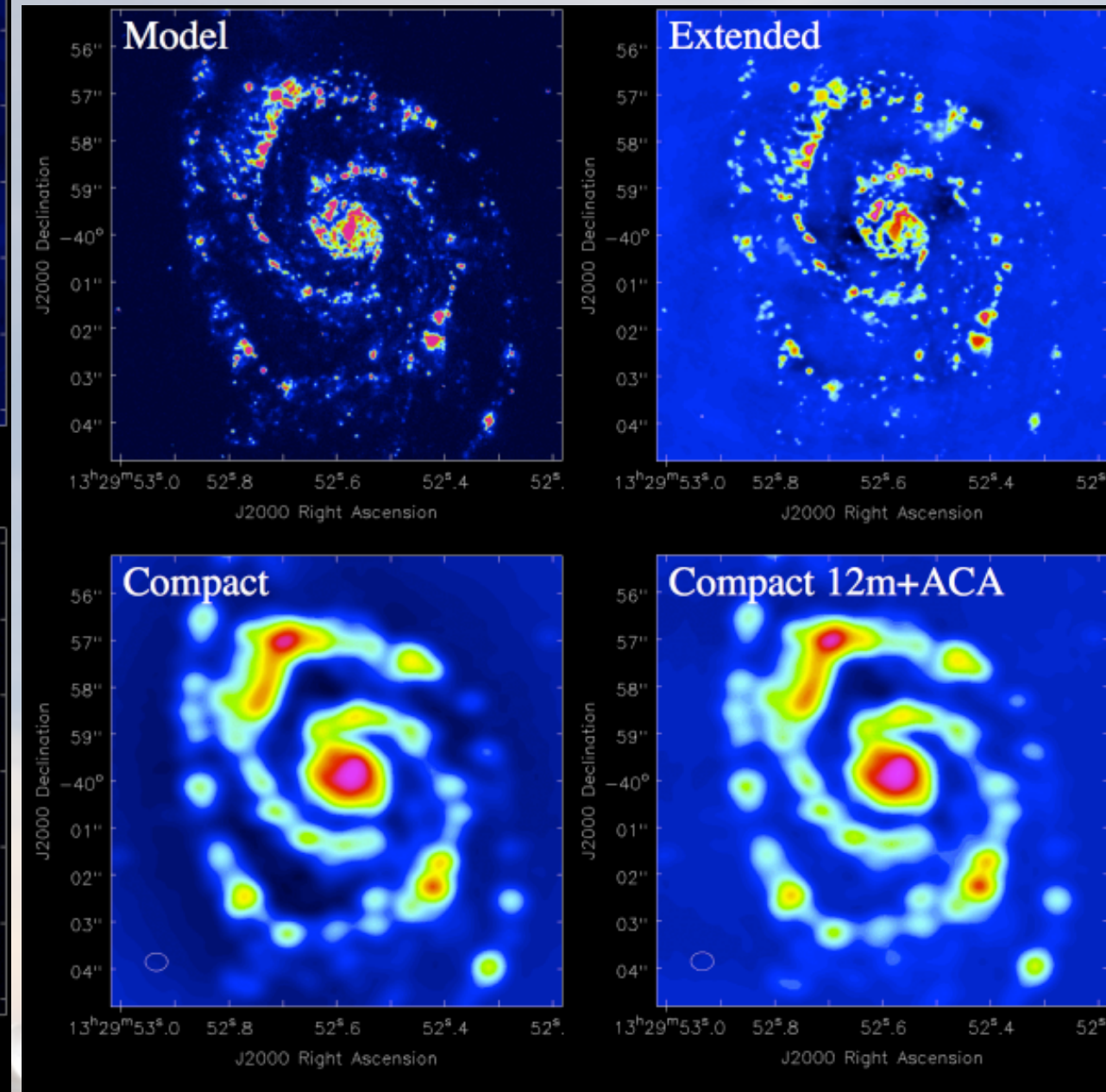
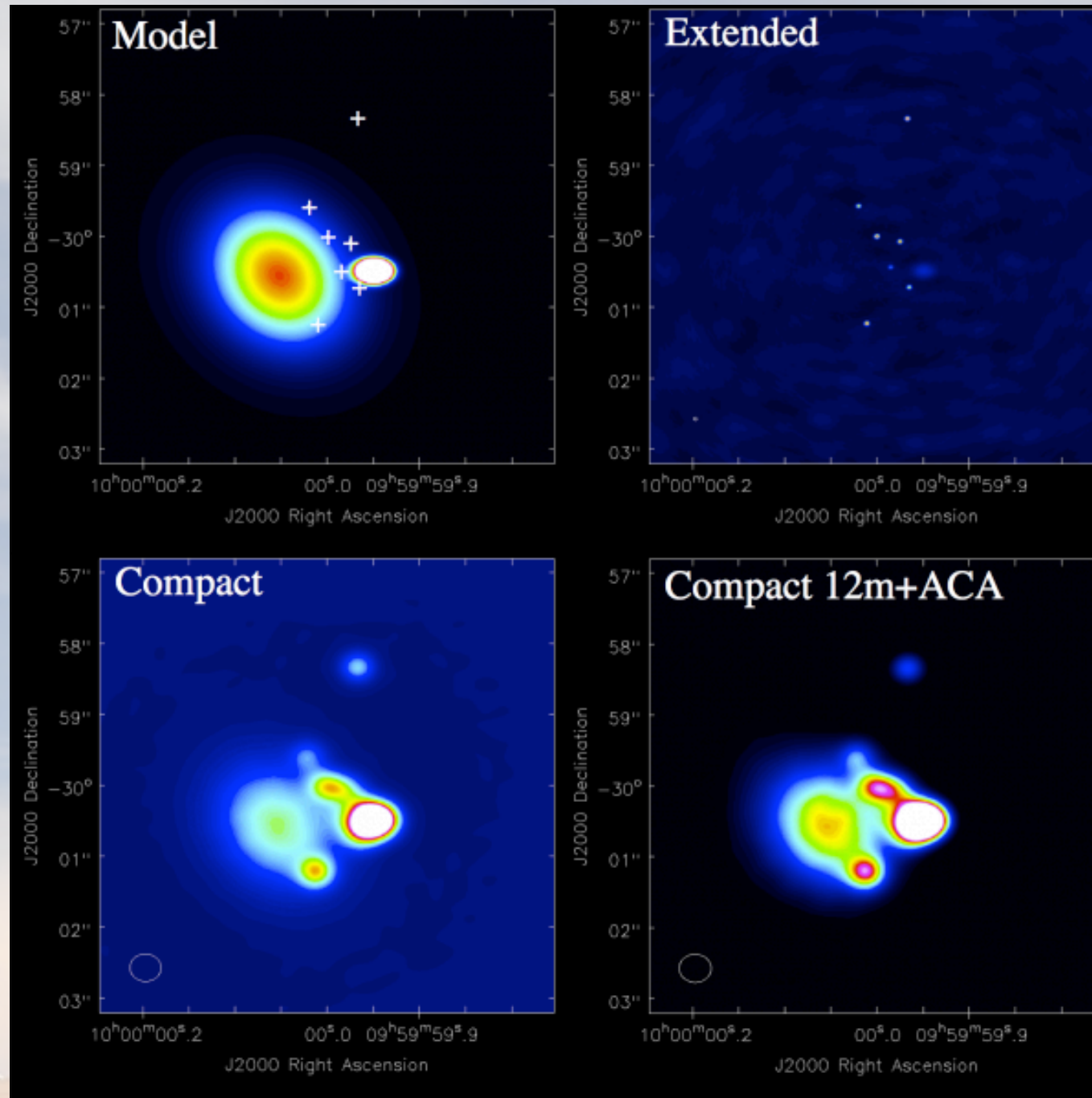


Why should I do an ALMA simulation ?

- You can try out different ALMA configurations and, for a given model, this might help you decide on the required angular resolution and maximum angular scale.
- A simulation can help support the required technical set-up in your proposal
- In particular, it can help you justify the need for complementary ACA/TP or, indeed, ACA-only observations.



Why should I do an ALMA simulation ?



source: CASA simulator pages

Available simulators

CASA simulator

ALMA Observation Support tool

```
# simobserve :: mosaic simulation task:
project          = 'sim'          # root prefix for output file names
skymodel         = '30dor.fits'   # model image to observe
inbright         = '0.06mJy/pixel' # scale surface brightness of brightest pixel e.g. "1.2Jy/pixel"
indirection      = 'J2000 19h00m00 -40d00m00' # set new direction e.g. "J2000 19h00m00 -40d00m00"
incell           = '0.15arcsec'   # set new cell/pixel size e.g. "0.1arcsec"
incenter         = '230GHz'       # set new frequency of center channel e.g. "89GHz" (required even for 2D model)
inwidth          = '2GHz'         # set new channel width e.g. "10MHz" (required even for 2D model)

complist         = ''             # componentlist to observe
setpointings     = True          # integration (sampling) time
integration      = '600s'        # "J2000 19h00m00 -40d00m00" or "" to center on model
direction        = ''            # angular size of map or "" to cover model
mapsize          = ['', '']      # hexagonal, square, etc
maptype          = 'topographic' # spacing in between pointings or "0.25PB" or "" for 0.5 PB
pointingspacing  = ''

obsnode          = 'int'         # observation mode to simulate
# [int(interferometer)|sd(singledish)|""(none)]
# antenna position file
antennalist      = '/usr/lib64/casapy/stable/data/alma/simmos/alma.cycle0.compact.cfg' # interferometer
# date of observation - not critical unless concatting simulations
refdate          = '2012/05/21'  # hour angle of observation center e.g. -3:00:00, or "transit"
hourangle        = 'transit'     # total time of observation or number of repetitions
totaltime        = '7200s'       # pt source calibrator [experimental]
caldirection     = ''
calflux          = '1Jy'

thermalnoise     = ''            # m|tsys-manual|""]
leakage          = 0.0            # rometer only)
graphics         = 'both'        # age to [screen|file|both|none]
verbose          = False
overwrite        = True
async            = False

# with $project
# e started using simobserve(...)
```



ALMA Observation Support Tool

OST NEWS HELP QUEUE LIBRARY ALMA HELPDESK

Important information on the new OST version.

Array Setup:

Instrument: [Select the desired ALMA antenna configuration.](#)

Sky Setup:

Source model: [Choose a library source model or supply your own.](#)

Upload: no file selected [You may upload your own model here \(max 10MB\)](#)

Declination: [Ensure correct formatting of this string \(+/-00d00m00.0s\)](#)

Image peak / point flux in [Rescale the image data with respect to new peak value. Set to 0.0 for no rescaling of source model.](#)

Observation Setup:

Observing mode: ☐ Spectral ☒ Continuum [Spectral or continuum observations?](#)

Central frequency in GHz: [The value entered must be within an ALMA band.](#)

Bandwidth in [Select the total bandwidth for continuum observation. Enter 7.5 GHz to select ALMA recommend full continuum.](#)

Number of polarizations: [This affects the noise in the final map.](#)

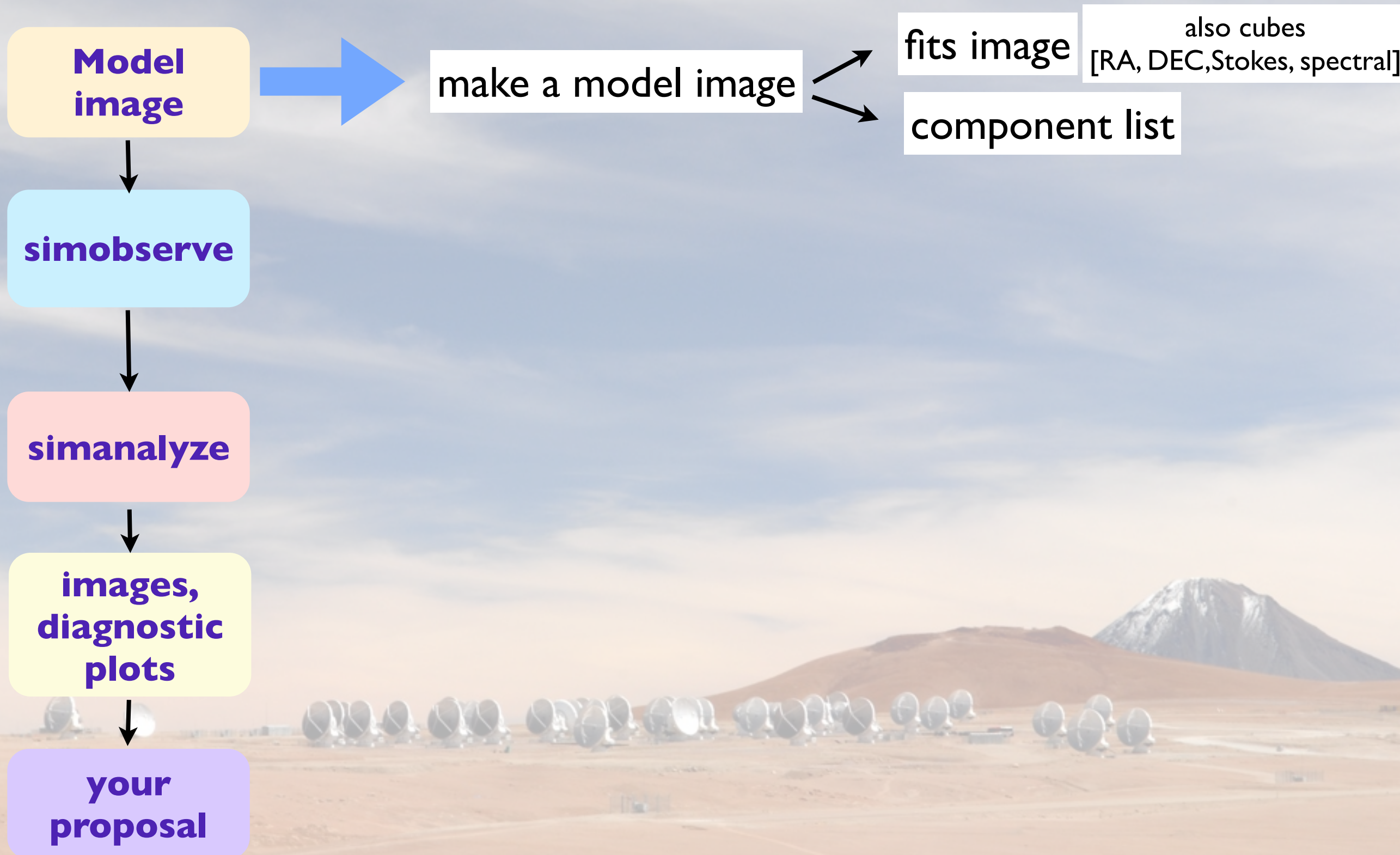
Required resolution in arcseconds: [OST will choose array config based on this value if not specified.](#)

Pointing strategy: [Selecting single will apply primary beam attenuation factor.](#)

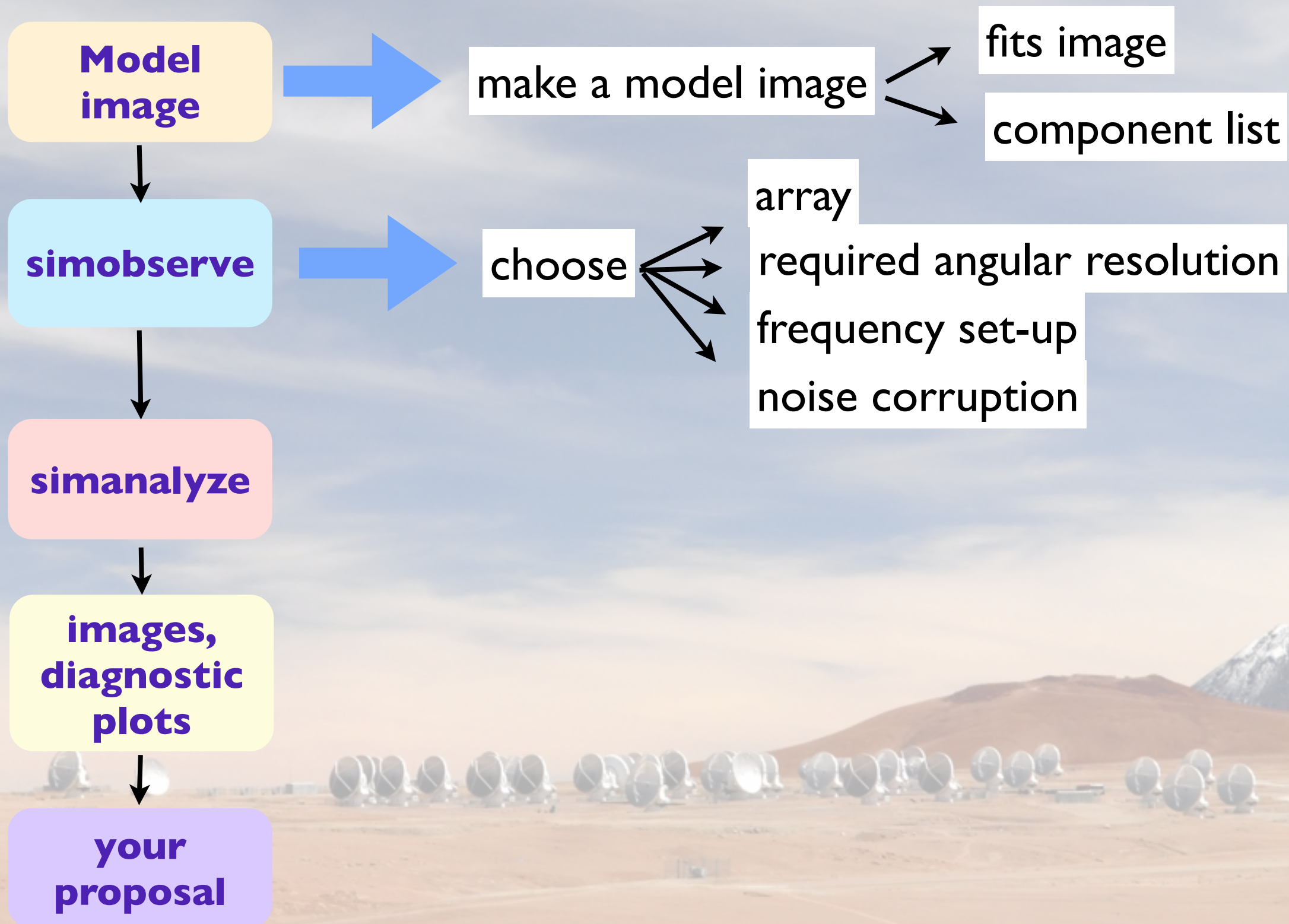
On-source time in [Per pointing for mosaics.](#)

Start hour angle: [Deviation of start of observation from transit.](#)

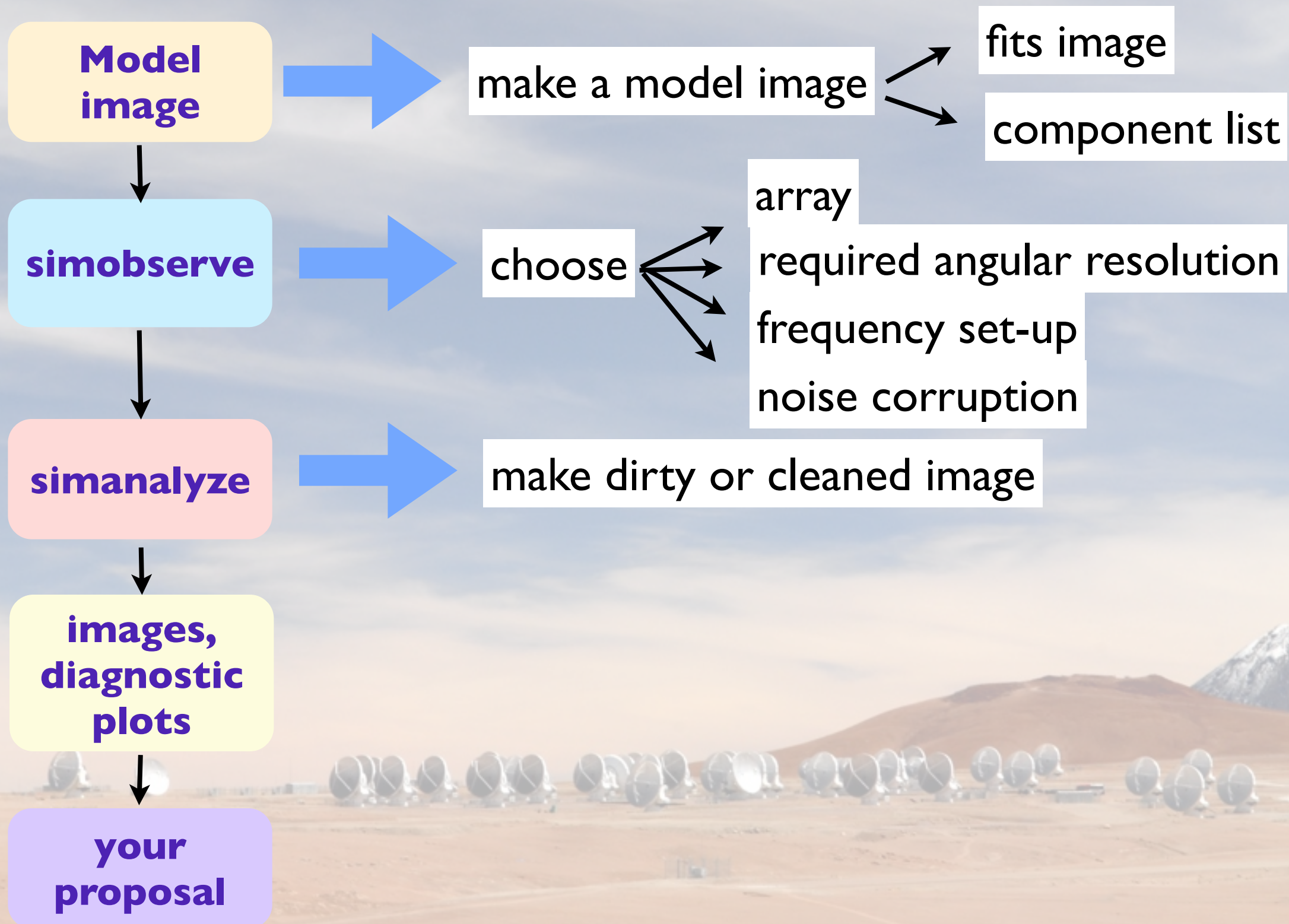
CASA simulator and cycle 5



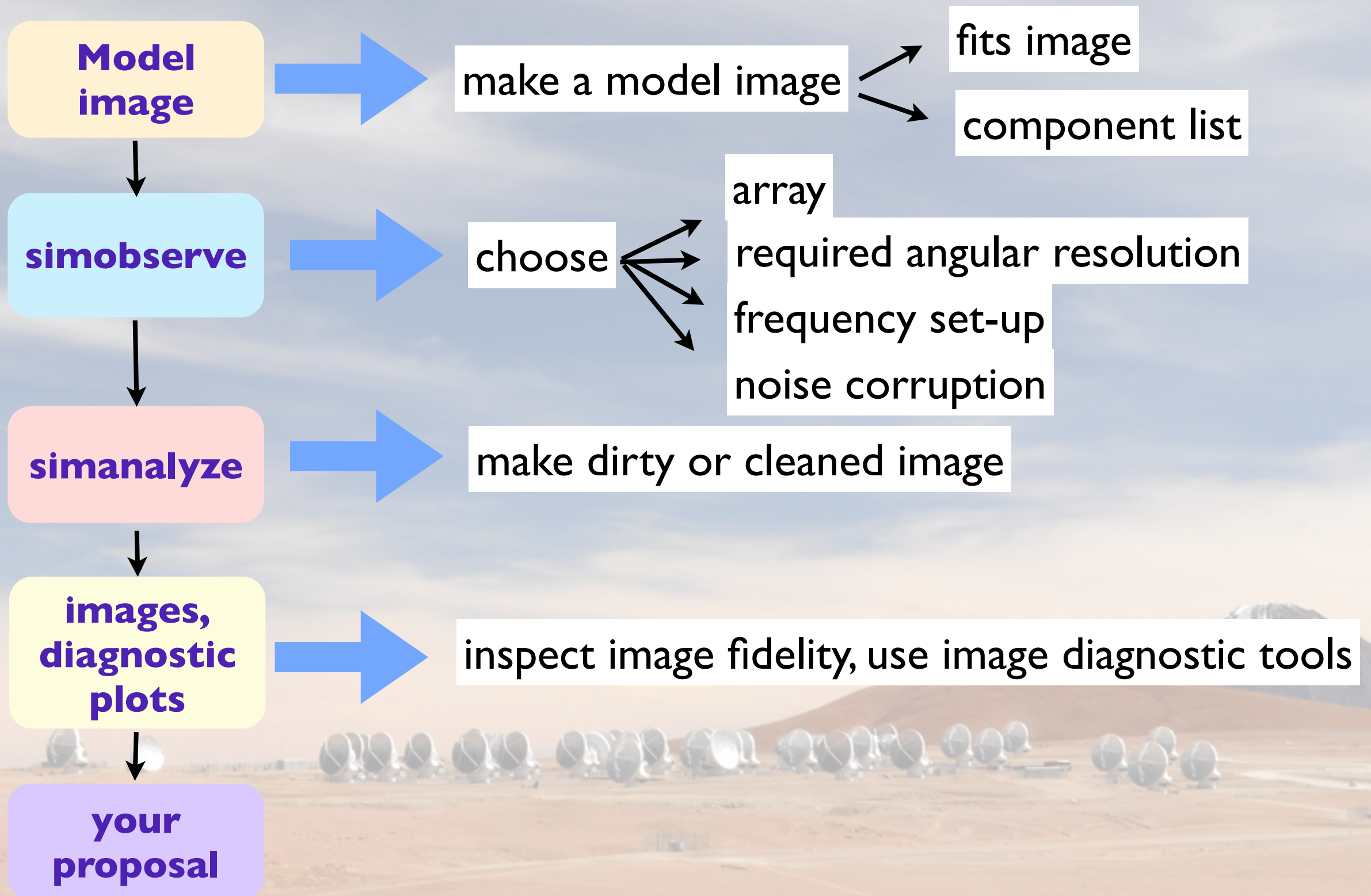
CASA simulator and cycle 5



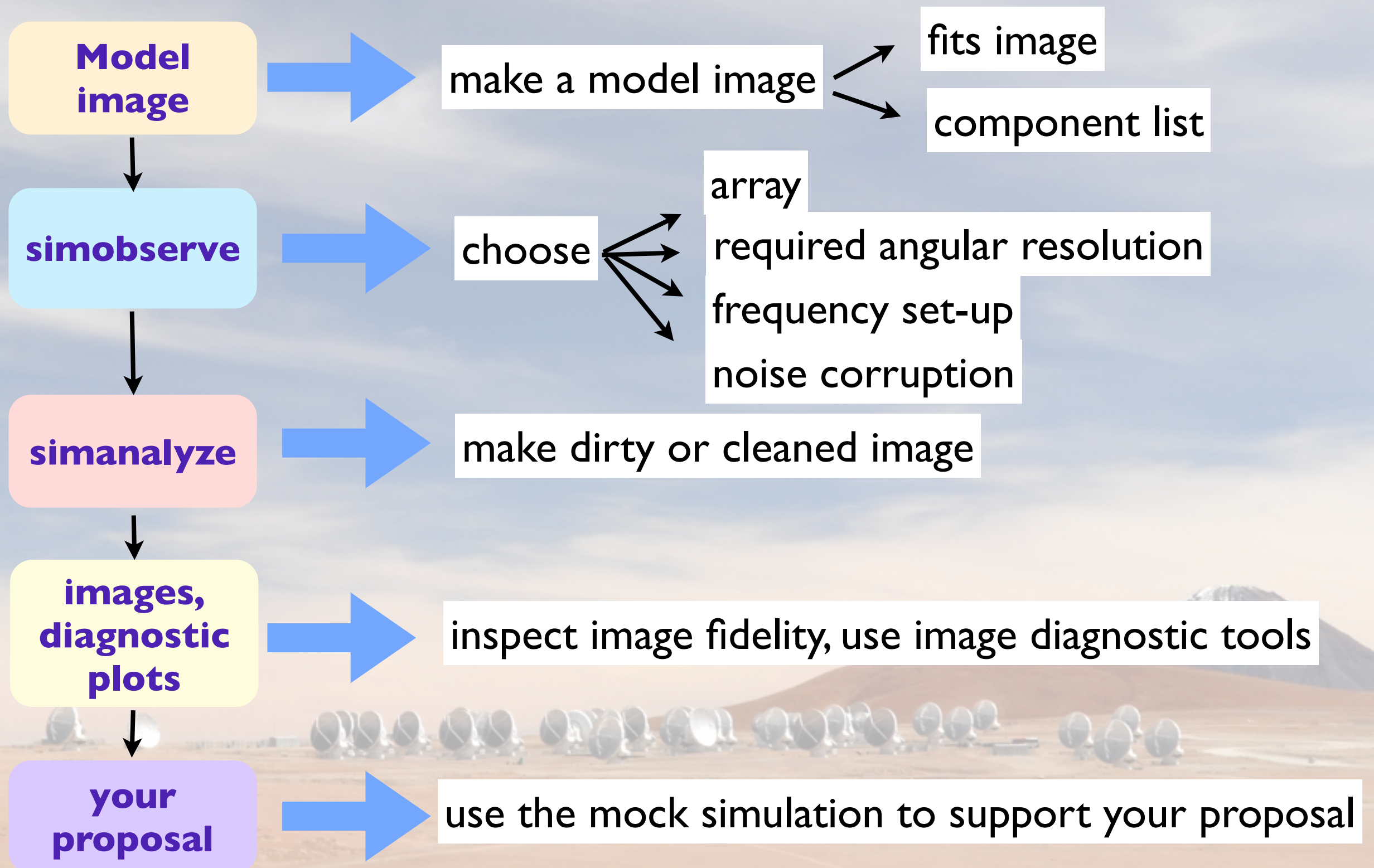
CASA simulator and cycle 5



CASA simulator and cycle 5



CASA simulator and cycle 5



Simobserve

```
# simobserve :: mosaic simulation task:
project          = 'sim'          # root prefix for output file names
skymodel         = '30dor.fits'   # model image to observe
  inbright       = '0.06mJy/pixel' # scale surface brightness of brightest pixel e.g. "1.2Jy/pixel"
  indirection    = 'J2000 10h00m00 -40d00m00' # set new direction e.g. "J2000 19h00m00 -40d00m00"
  incell         = '0.15arcsec'    # set new cell/pixel size e.g. "0.1arcsec"
  incenter       = '230GHz'        # set new frequency of center channel e.g. "89GHz" (required even for
                                     # model)
  inwidth        = '2GHz'          # set new channel width e.g. "10MHz" (required even for 2D model)

complist         = ''             # componentlist to observe
setpointings     = True           #
  integration    = '600s'         # integration (sampling) time
  direction      = ''             # "J2000 19h00m00 -40d00m00" or "" to center on model
  mapsize        = ['', '']       # angular size of map or "" to cover model
  maptype        = 'topographic'   # hexagonal, square, etc
  pointingspacing = ''            # spacing in between pointings or "0.25PB" or "" for 0.5 PB

obsmode          = 'int'          # observation mode to simulate
                                     # [int(interferometer)|sd(singledish)|""(none)]
  antennalist    = '/usr/lib64/casapy/stable/data/alma/simmos/alma.cycle0.compact.cfg' # interferometer
                                     # antenna position file
  refdate        = '2012/05/21'   # date of observation - not critical unless concatting simulations
  hourangle      = 'transit'       # hour angle of observation center e.g. -3:00:00, or "transit"
  totaltime      = '7200s'        # total time of observation or number of repetitions
  caldirection   = ''             # pt source calibrator [experimental]
  calflux        = '1Jy'          #

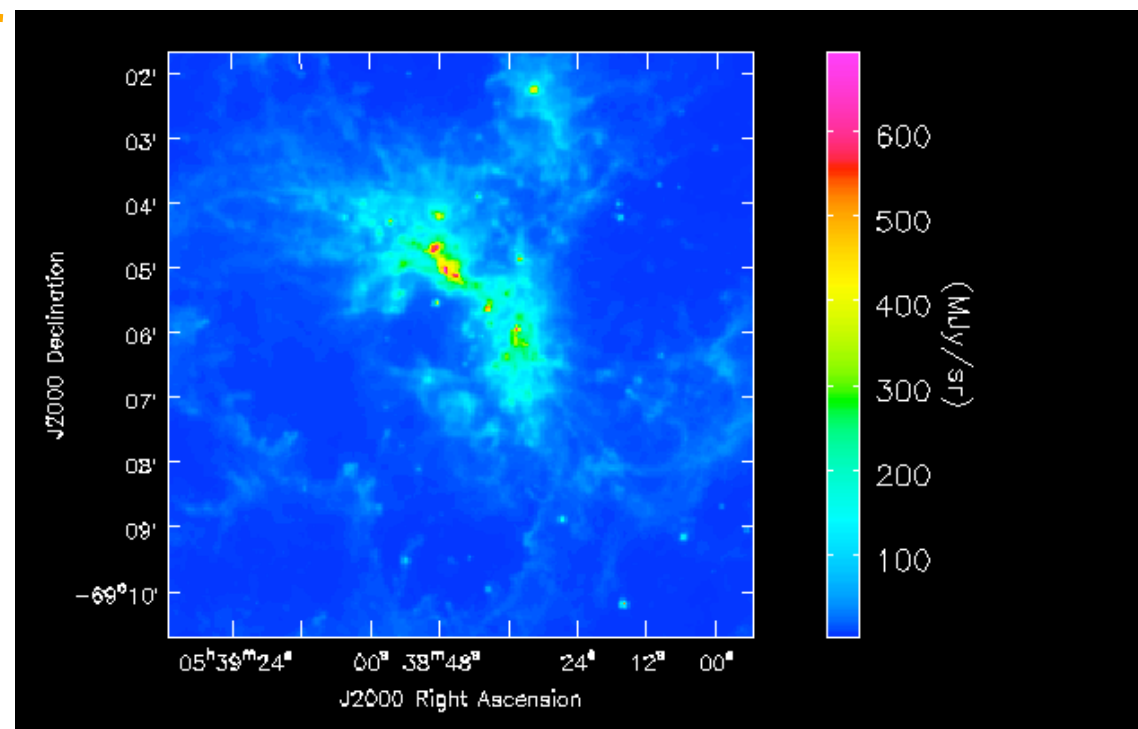
thermalnoise     = ''             # add thermal noise: [tsys-atm|tsys-manual|""]
leakage          = 0.0             # cross polarization (interferometer only)
graphics         = 'both'         # display graphics at each stage to [screen|file|both|none]
verbose          = False          #
overwrite        = True           # overwrite files starting with $project
async            = False          # If true the taskname must be started using simobserve(...)
```

Simobserve

```
# simobserve :: mosaic simulation task:
project          = 'sim'          # root prefix for
skymodel         = '30dor.fits'   # model image to
    inbright      = '0.06mJy/pixel' # scale surface
    indirection   = 'J2000 10h00m00 -40d00m00' # set
    incell        = '0.15arcsec'   # set new cell
    incenter      = '230GHz'       # set new freq
                                     # model)
    inwidth       = '2GHz'         # set new chan

complist         = ''             # component list
```

**Model
image**



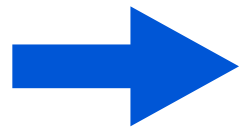
Spitzer IRAC 89 micron
image of 30 Doradus

Simobserve

interferometer (int) or single-dish (sd)

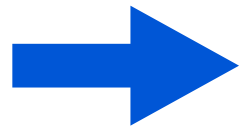


```
obsmode = 'int' # observation mode to simulate  
# [int(interferometer)|sd(singledish)|""(none)]  
antennalist = '/usr/lib64/casapy/stable/data/alma/simmos/alma.cycle0.compact.cfg'
```



Cycle 5 representative configurations files

<http://almascience.org/documents-and-tools/cycle5/alma-configuration-files>



or, give the required angular resolution

"alma;0.5arcsec"

(only works for full ALMA !)



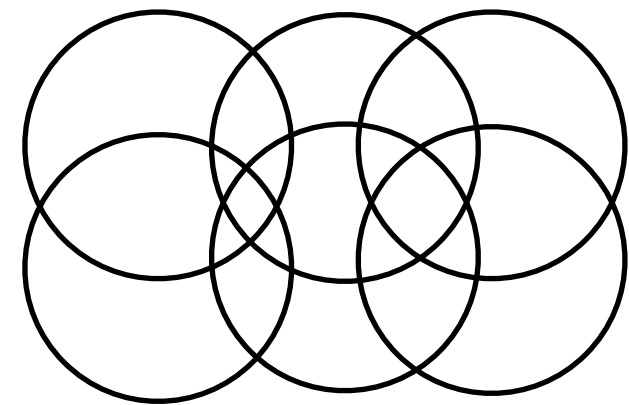
Simobserve

```
incenter = '230GHz'
```

```
inwidth = '2GHz'
```

spectral set-up

```
complist = ''  
setpointings = True  
integration = '600s'  
direction = ''  
mapsize = ['', '']  
maptype = rectangle or hexagonal  
pointingspacing = ''
```



the simulator allows you to
test
several pointing scenarios

observing
time and
pointing

Simobserve

```
# simobserve :: mosaic simulation task:
```

```
project = 'sim'
```

```
skymodel = '30dor.fits'
```

```
inbright = '0.06mJy/pixel'
```

```
indirection = 'J2000 10h00m00 -40d00m00'
```

```
incell = '0.15arcsec'
```

```
incenter = '230GHz'
```

```
inwidth = '2GHz'
```

model image

spectral set-up

```
complist = ''
```

```
setpointings = True
```

```
integration = '600s'
```

```
direction = ''
```

```
mapsize = ['', '']
```

```
maptype = 'topographic'
```

```
pointingspacing = ''
```

observing
time and
pointing

```
obsmode = 'int'
```

```
antennalist = '/usr/lib64/casapy/stable/data/alma/simmos/alma.cycle0.compact.cfg' # inter
```

```
refdate = '2012/05/21'
```

```
hourangle = 'transit'
```

```
totaltime = '7200s'
```

```
caldirection = ''
```

```
calflux = '1Jy'
```

array choice
or
required
angular
resolution

```
thermalnoise = 'tsys-atm'
```

```
user_pwv = 1.0
```

```
t_ground = 269.0
```

```
seed = 11111
```

noise
addition

```
leakage = 0.0
```

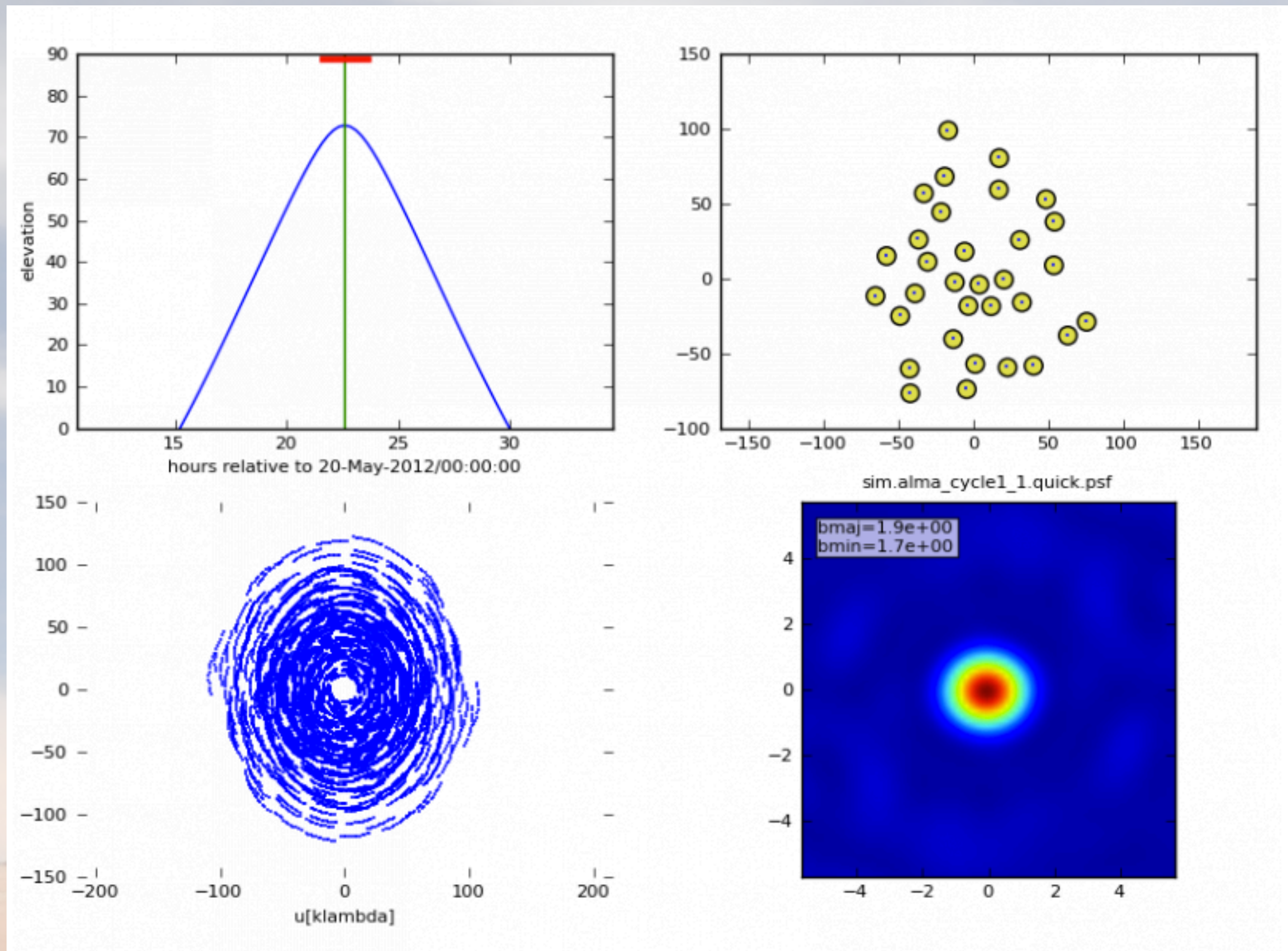
```
graphics = 'both'
```

```
verbose = False
```

```
overwrite = True
```

```
async = False
```

Simobserve



Imaging step

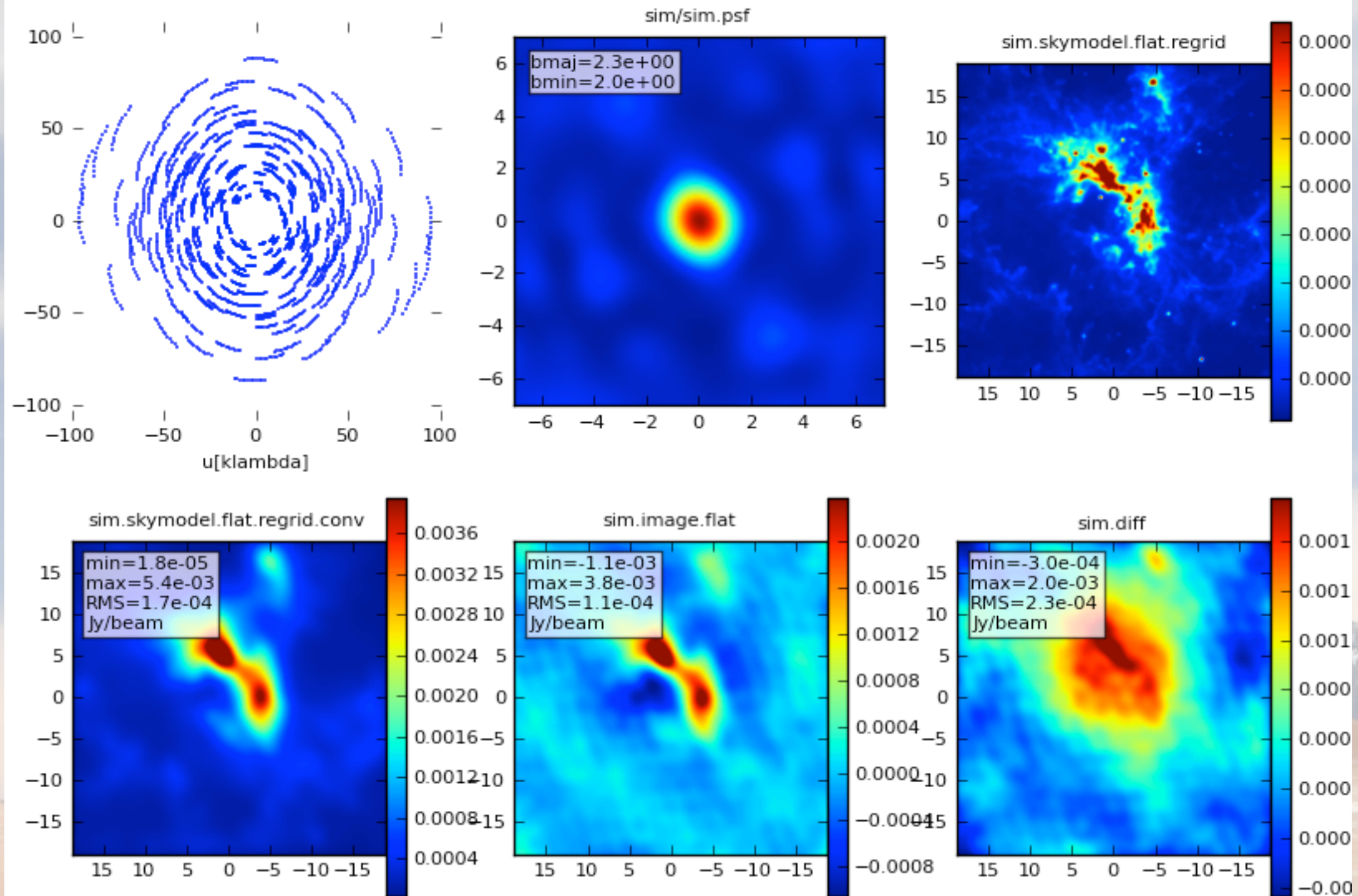
simanalyze

```
# simanalyze :: image and analyze simulated datasets
project          = 'sim'          # root prefix for output file names
image            = True           # (re)image $project.*.ms to $project.image
  vis            = 'default'      # Measurement Set(s) to image
  modelimage     = ''            # prior image to use in clean e.g. existing single dish image
  imsize         = 0             # output image size in pixels (x,y) or 0 to match model
  imdirection    = ''            # set output image direction, (otherwise center on the model)
  cell           = ''            # cell size with units or "" to equal model
  niter          = 500           # maximum number of iterations (0 for dirty image)
  threshold      = '0.1mJy'      # flux level (+units) to stop cleaning
  weighting      = 'natural'     # weighting to apply to visibilities
  mask           = []            # Cleanbox(es), mask image(s), region(s), or a level
  outertaper     = []            # uv-taper on outer baselines in uv-plane
  stokes         = 'I'           # Stokes params to image

analyze          = True          # (only first 6 selected outputs will be displayed)
  showuv         = True          # display uv coverage
  showpsf        = True          # display synthesized (dirty) beam (ignored in single dish simulation)
  showmodel      = True          # display sky model at original resolution
  showconvolved  = False         # display sky model convolved with output beam
  showclean      = True          # display the synthesized image
  showresidual   = False         # display the clean residual image (ignored in single dish simulation)
  showdifference = True          # display difference image
  showfidelity   = True          # display fidelity

graphics        = 'both'        # display graphics at each stage to [screen|file|both|none]
verbose         = False
overwrite       = True          # overwrite files starting with $project
async          = False          # If true the taskname must be started using simanalyze(...)
```

Simanalyze imaging output

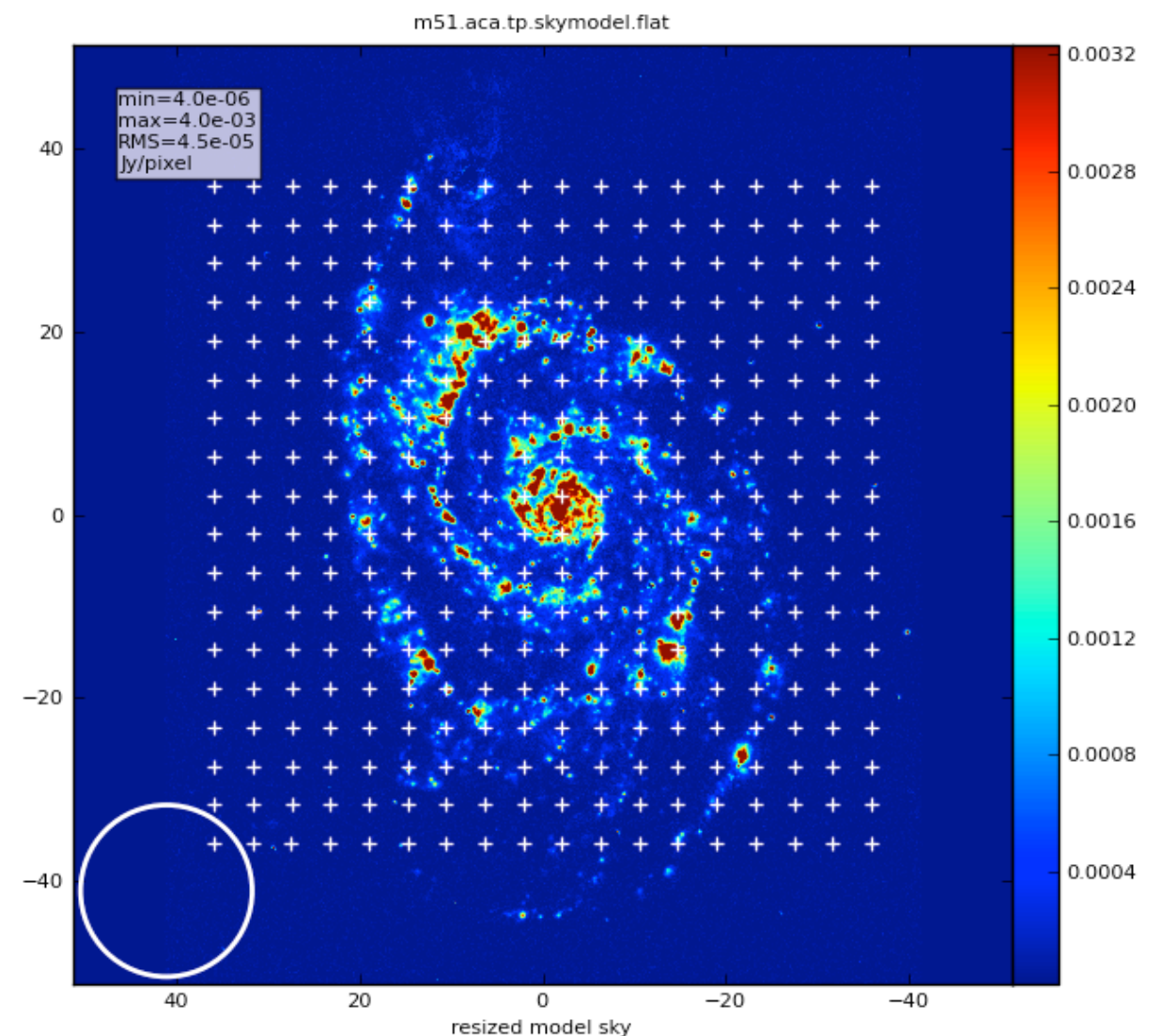
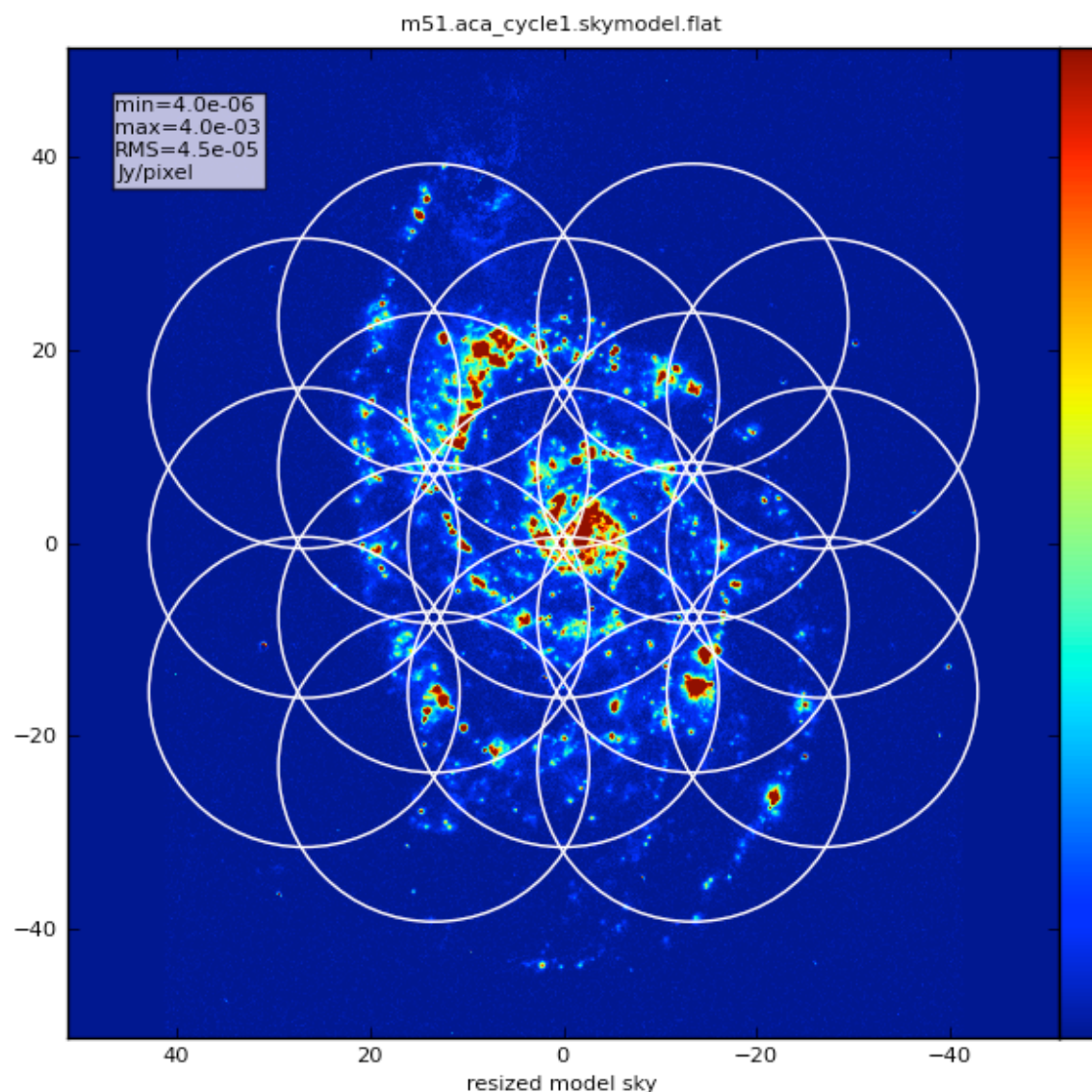


Simalma - combination of SD/ACA/ALMA during de-convolution

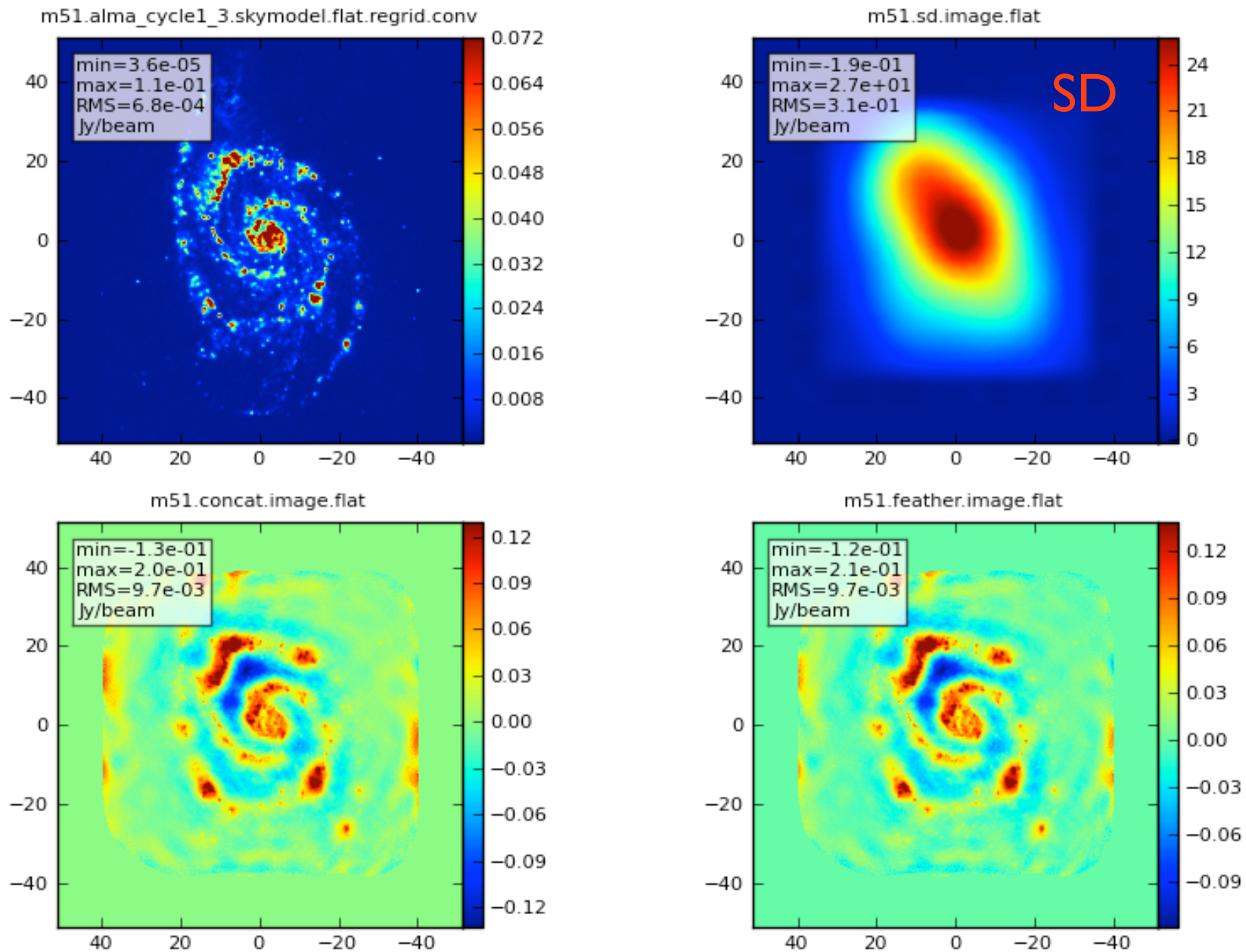
input model and pointing



M5 I input

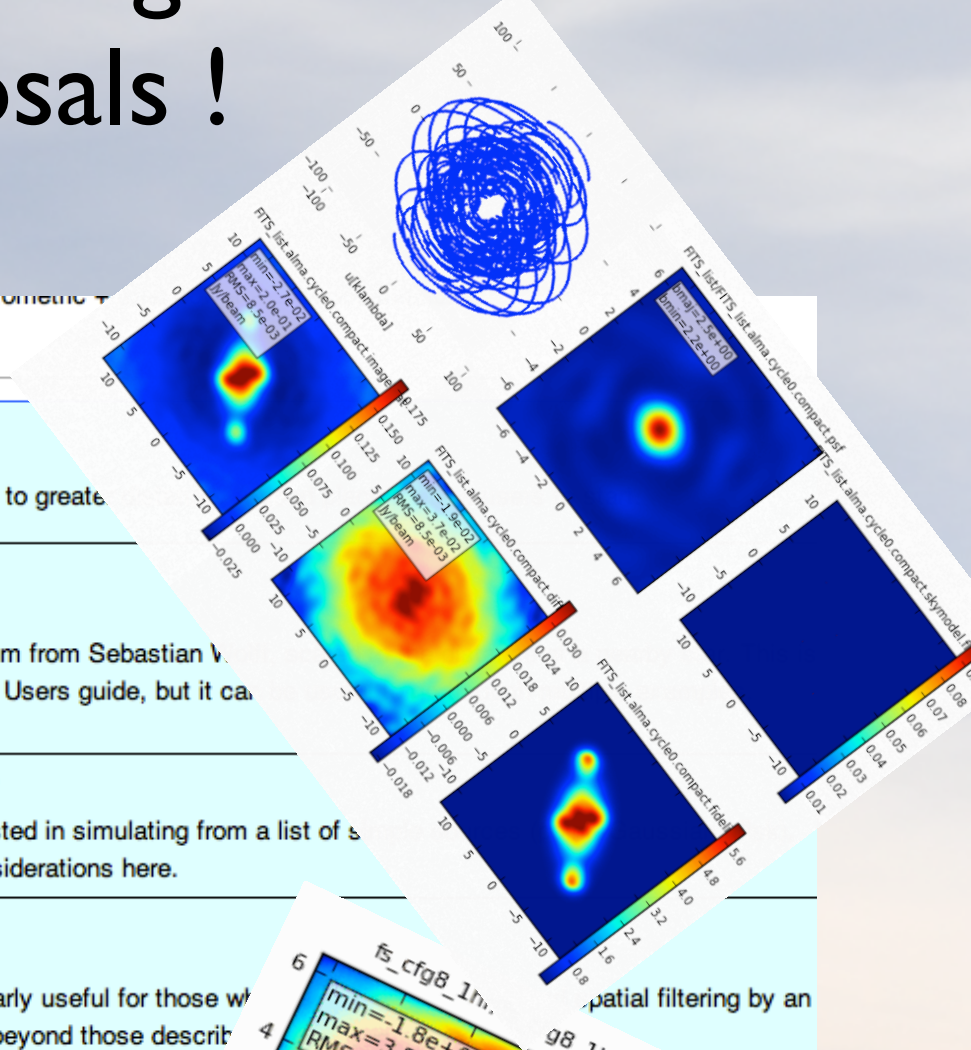
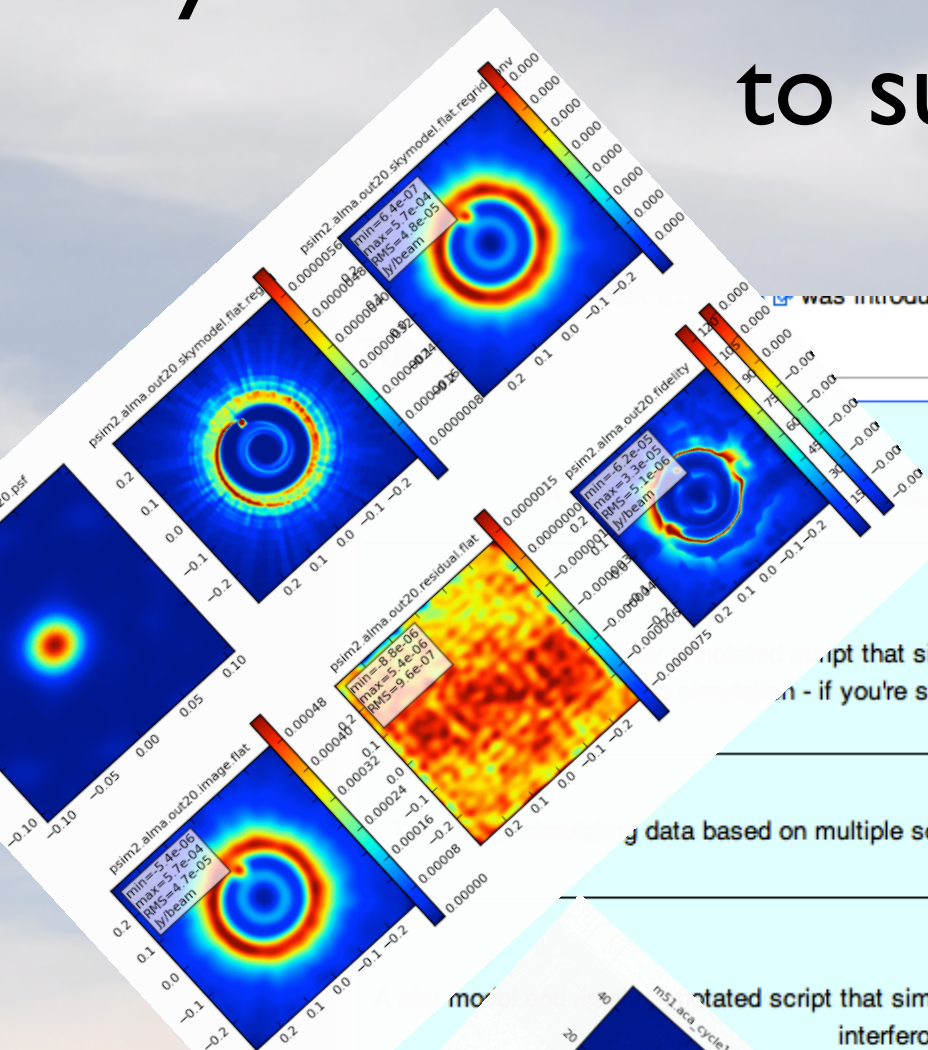


Simalma - combination of SD/ACA/ALMA during de-convolution



Useful examples

simulators and have fun using the simulations
to support your proposals !



Simulation Guide for New Users (CASA 4.3)

a Spitzer SAGE 8 micron continuum image of 30 Doradus and scales it to create

Protoplanetary Disk Simulation (CASA 4.3)

Script that simulates a protoplanetary disk. Uses a theoretical model of dust continuum from Sebastian V.
 on - if you're short on time, you probably don't need to go through this one and the New Users guide, but it ca.

Simulation Guide Component Lists (CASA 4.3)

data based on multiple sources (using both a FITS image and a component list). If you are interested in simulating from a list of sources rather than or in addition to a sky model image, then read the considerations here.

Einstein-Face (CASA 4.3)

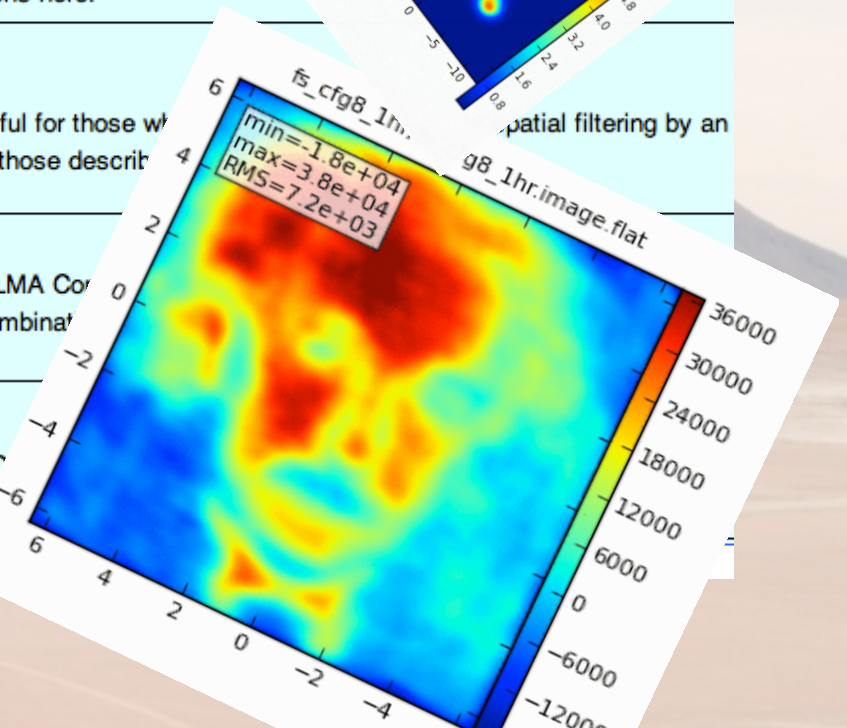
motivated script that simulates the face of Einstein as seen by ALMA. This simulation is particularly useful for those who use the interferometer, but doesn't demonstrate new capabilities of the simulation tasks beyond those described in the previous section.

ACA Simulation (CASA 4.3)

that use multiple configurations or use the 12-meter array in combination with the ALMA Correlator. This mode of operation is of particular interest to those wishing to explore using the 12-m array in combination with the 70-m array from multiple 12-m array configurations.

Simalma (CASA 4.3)

simplifies simulations that include the main 12-m array plus the ACORN and ACA arrays, and is also useful for those wishing to explore multi-component ALMA observations.



more complicated sims

Use the sm tool for:

phase delay variations

gain fluctuations and drift

cross-polarization

(soon also bandpass and pointing errors)

more flexibility in adding thermal noise

Thermal noise addition

<https://safe.nrao.edu/wiki/pub/ALMA/SimulatorCookbook/corruptguide.pdf>

simple: specify **simplenoise**="1Jy" to get random Gaussian noise with 1Jy RMS

- **tsys-atm:** use environment temperatures, antenna parameters, and the aatm library to create a model of the troposphere and add random noise of the appropriate magnitude to the visibilities
- **tsys-manual:** specify atmospheric brightness temperature and optical depth yourself (rather than let aatm calculate it for you) and apply noise of the corresponding magnitude.

