NAASC

An Introduction to Simdata

NRAO

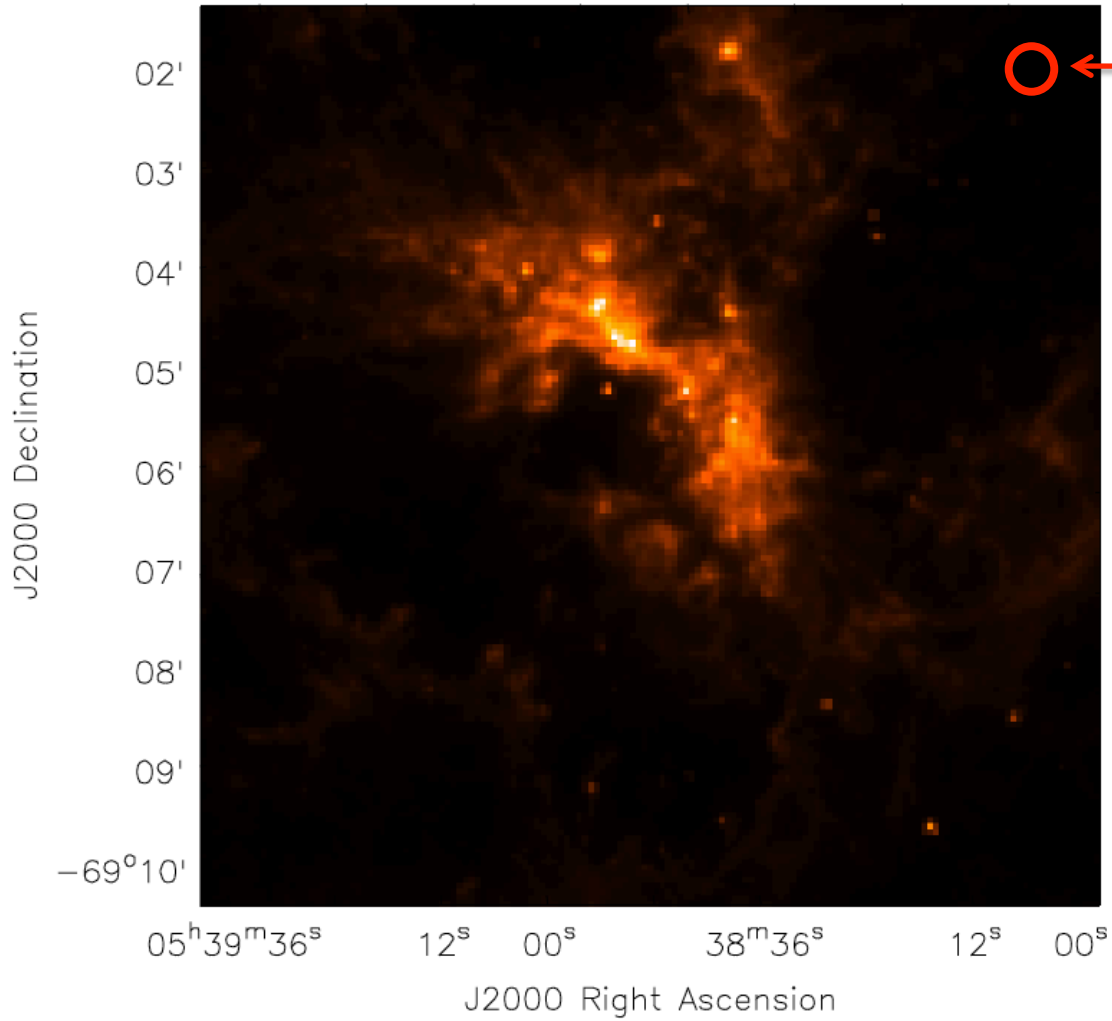
What is Simdata Good For?

Take a model image and find out how it would look if observed with ALMA

- Number of antennas
- Antenna configuration
- Length of observation
- Noise* ⟵
  - Thermal Noise
  - Phase Noise

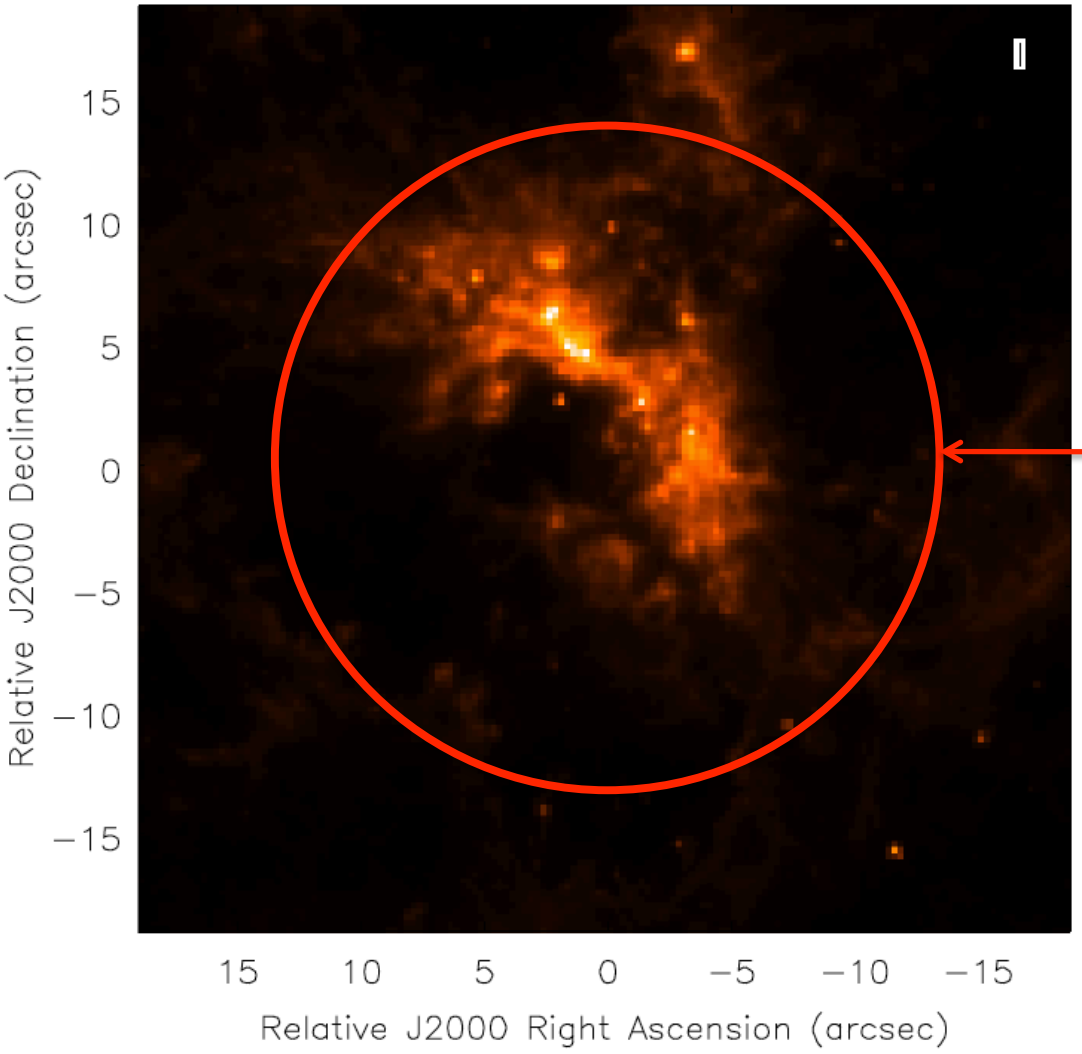
Model Image

30Dor Spitzer IRAC 8um image from SAGE



NAASC

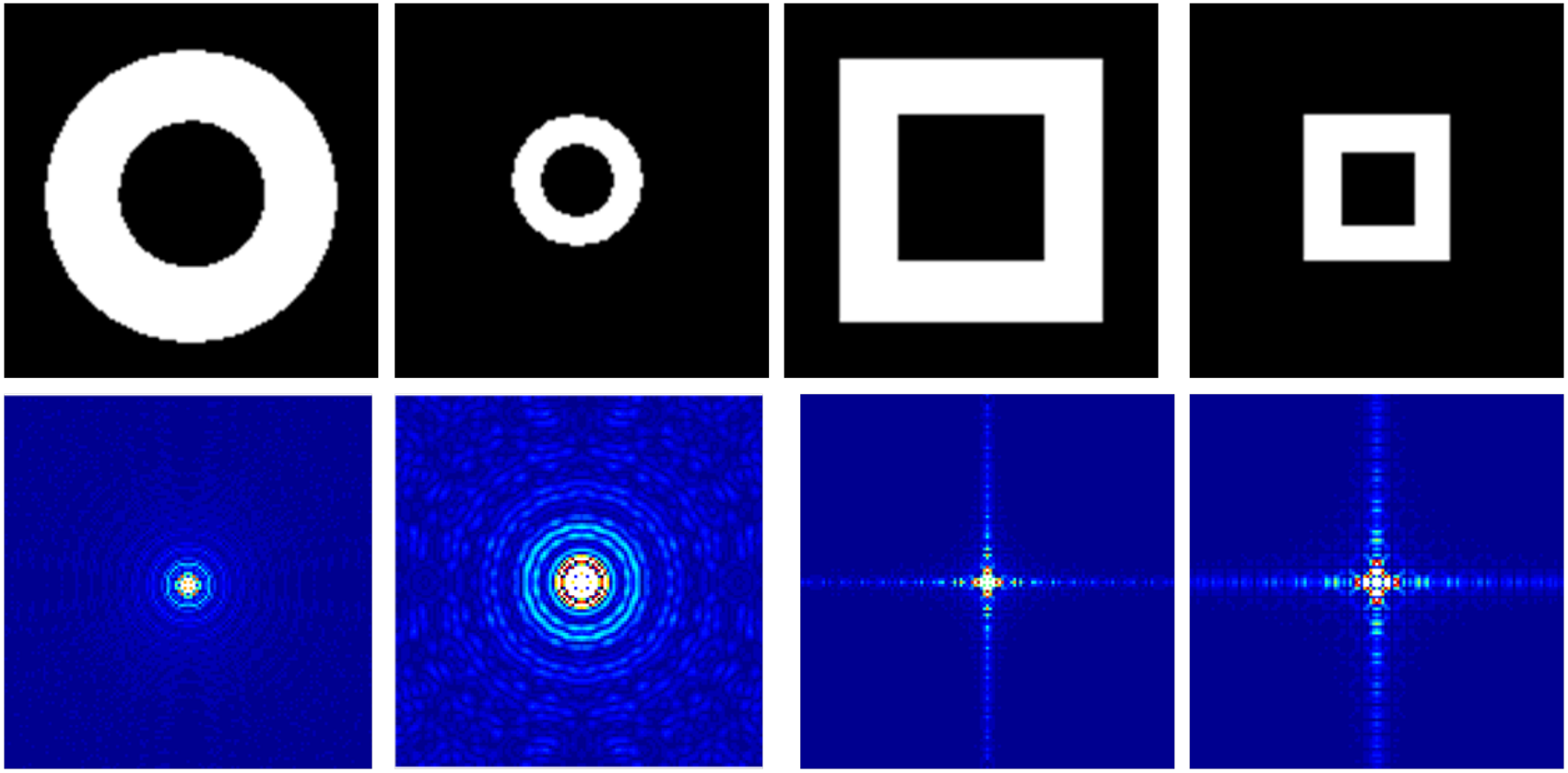
Model Image
Resized and now at 230 GHz



Field of view
at 230 GHz

NRAO

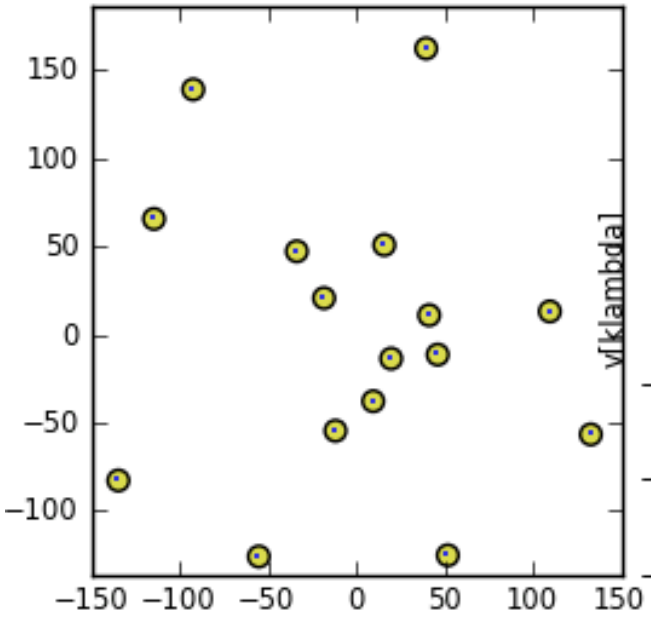
Fourier Transforms of Images



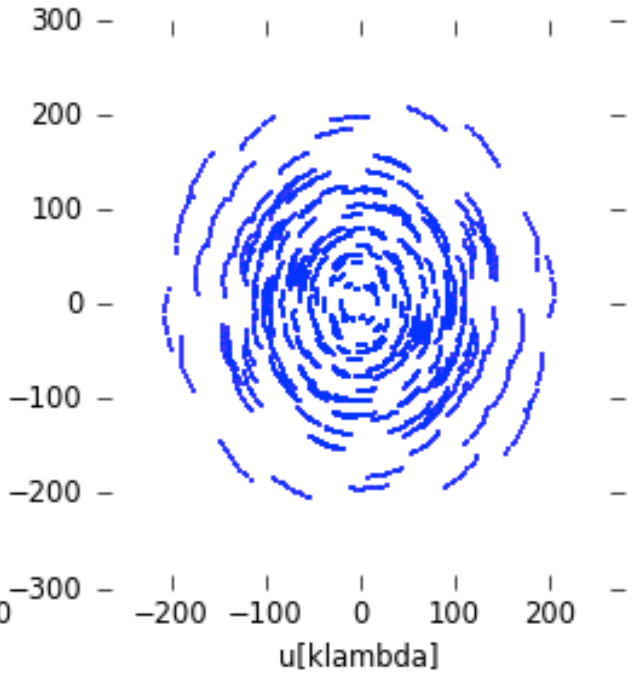
From http://carmilumban-ap186.blogspot.com

Scales Measured in Early Science

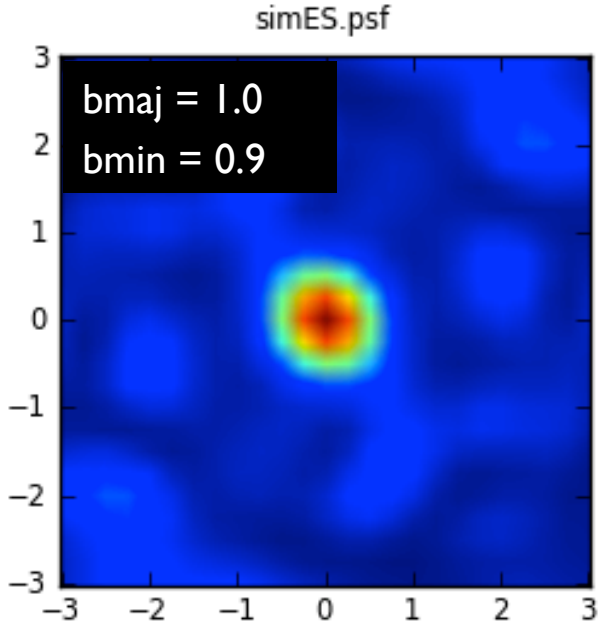
Antenna Placement



uv-coverage



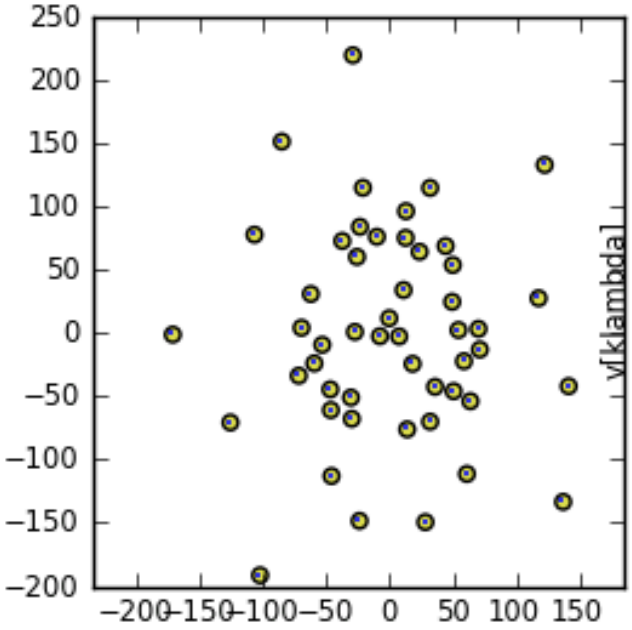
Point Spread Function



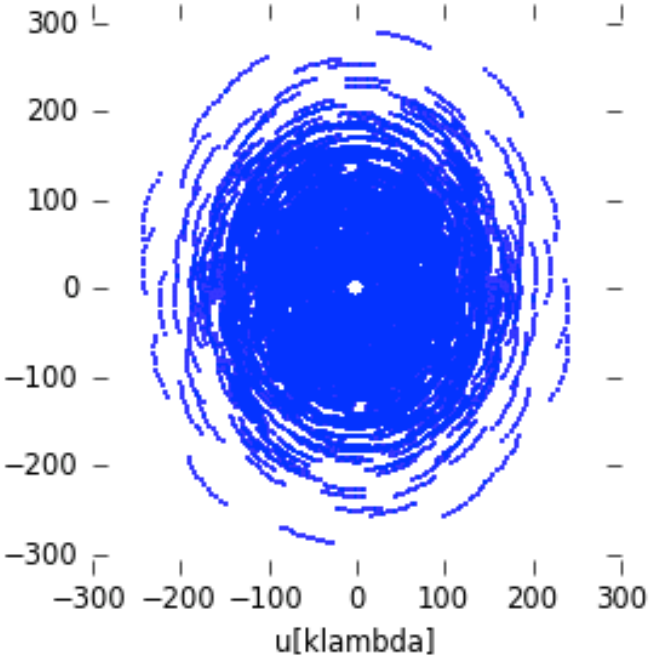
2 hour observation

Full Science 12m Array - Compact

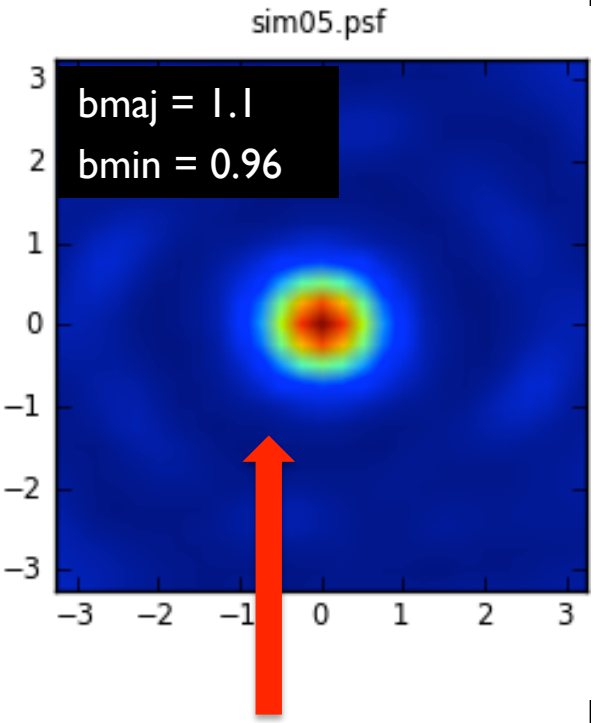
Antenna Placement



uv-coverage



synthesized beam

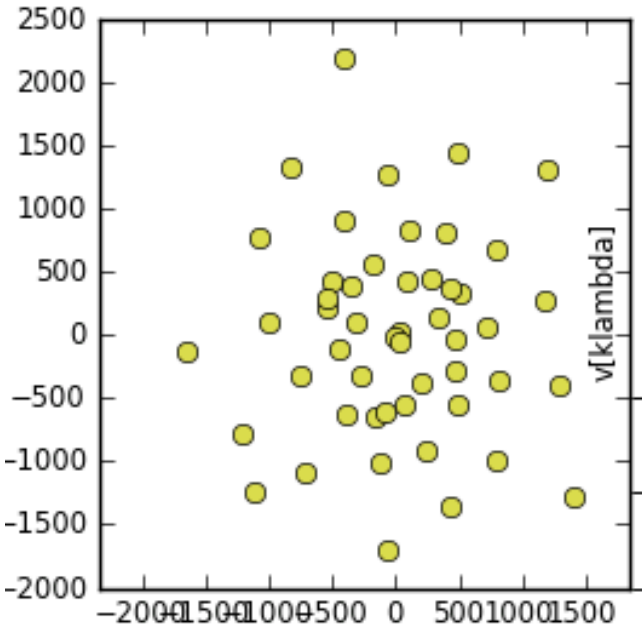


2 hour observation

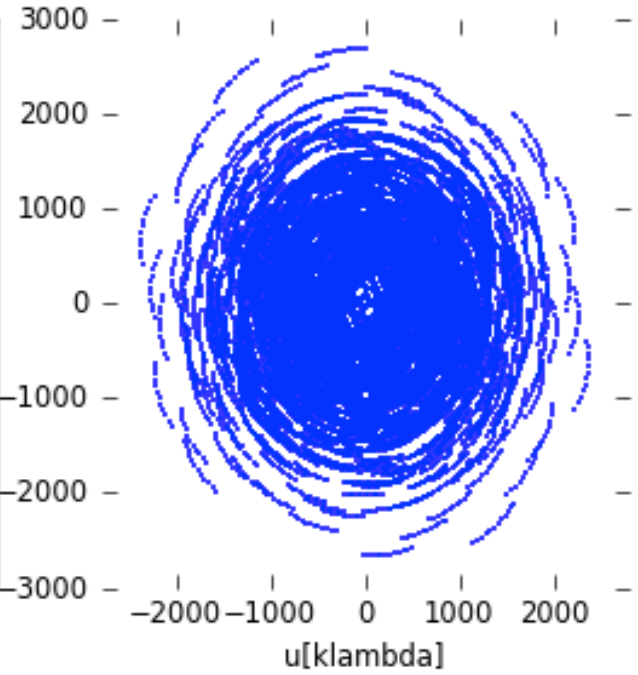
Note lower sidelobes

Full Science 12m Array - Extended

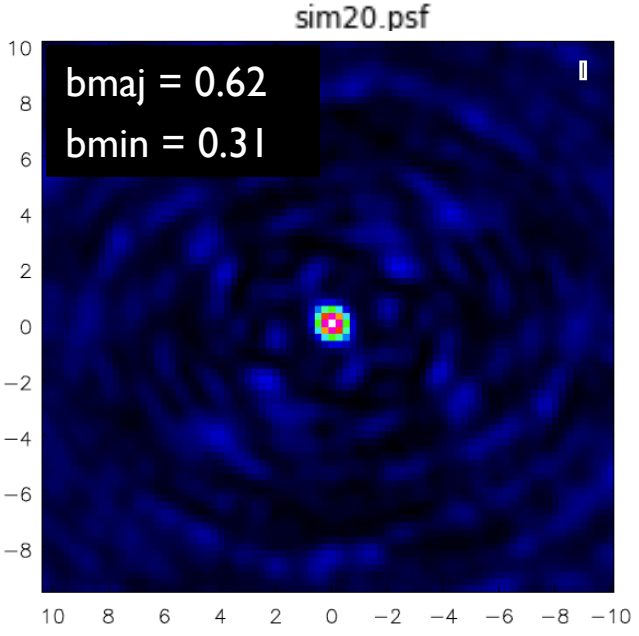
Antenna Placement



uv-coverage



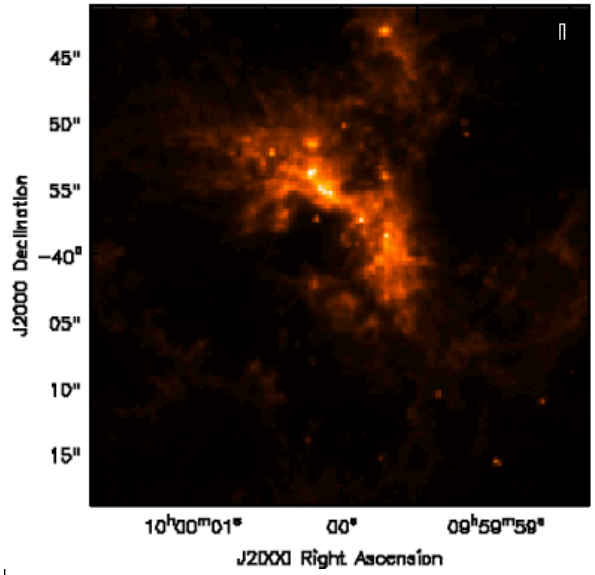
synthesized beam



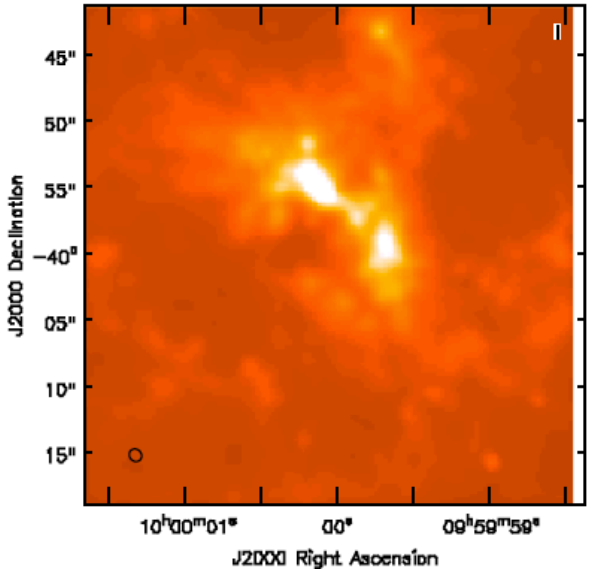
2 hour observation

Model: Early Science Configuration

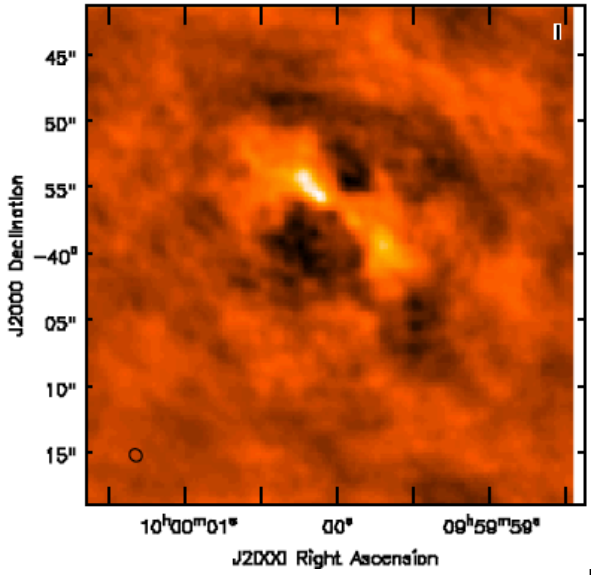
Model Image



Convolved Model



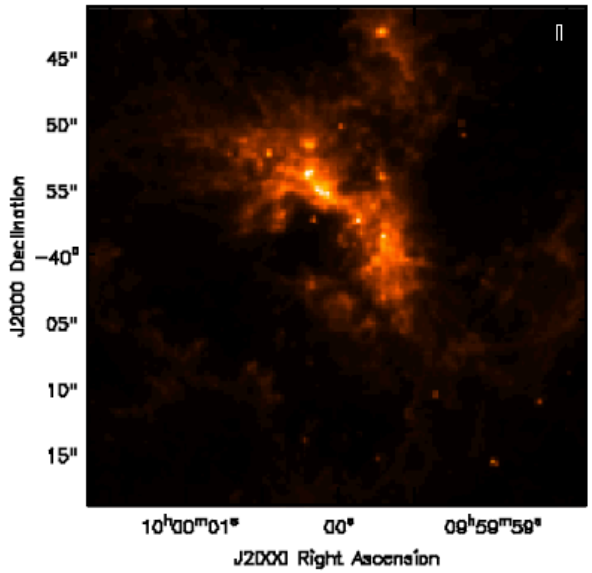
"Observed" Image



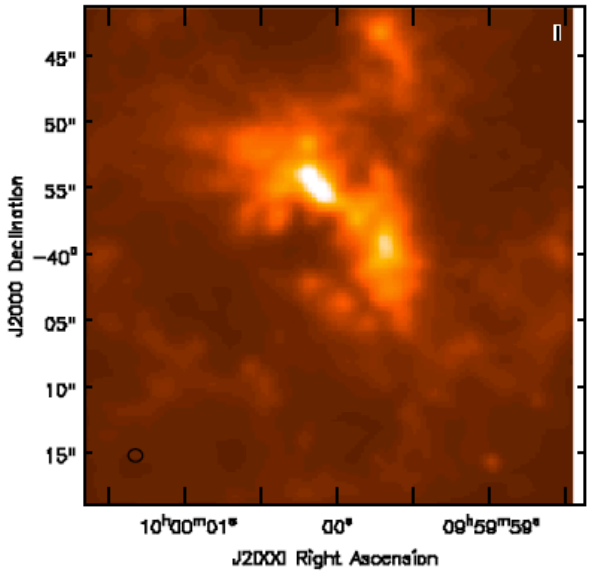
2 hour observation

Model: Full Science Main Array - Compact

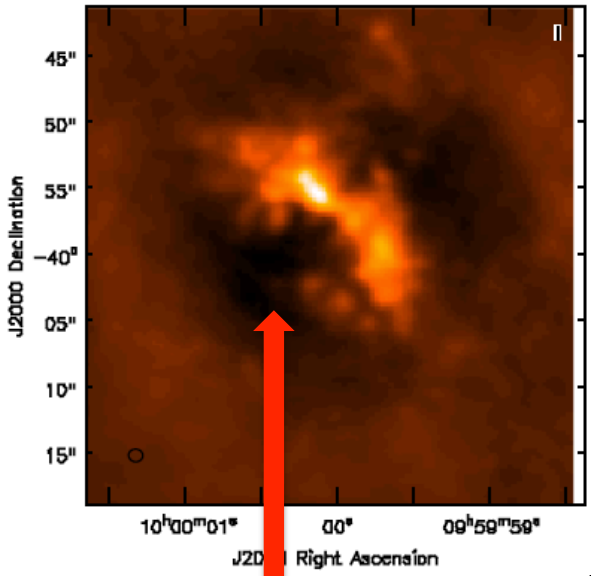
Model Image



Convolved Model



"Observed" Image

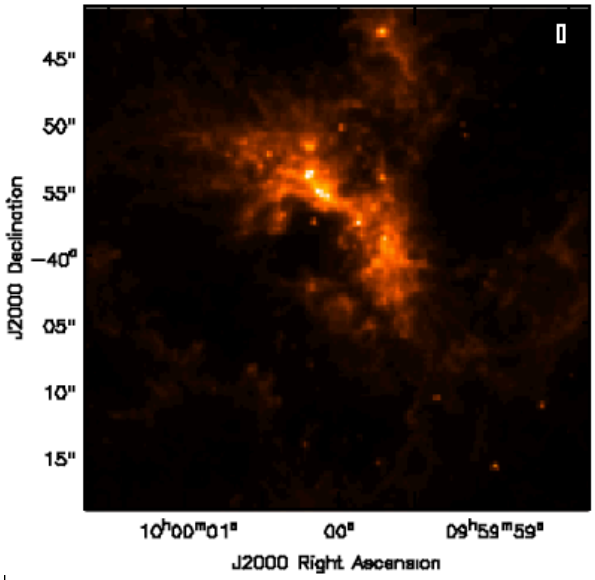


2 hour observation

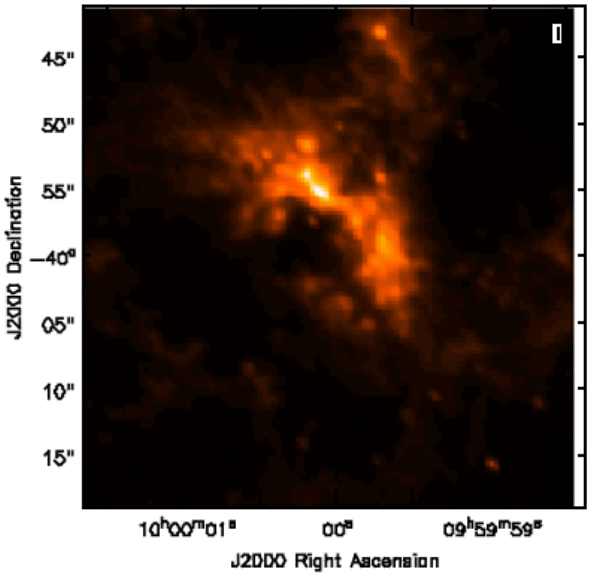
Large scale emission: Observe with ACA and possibly TPA

Model: Full Science Main Array - Extended

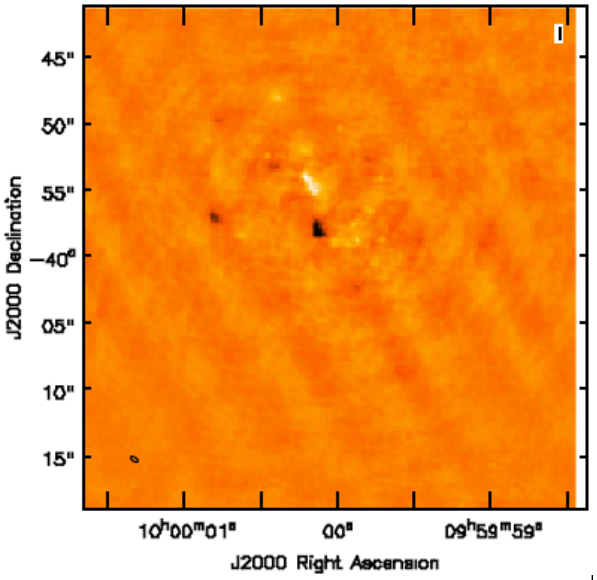
Model Image



Convolved Model



"Observed" Image



2 hour observation

Basic Simdata Workflow

- Start CASA
- Input image file into Simdata
- Predict what ALMA would see using Simdata
- Compare ALMA image with input image

Basic Simdata Inputs

- Image of target
- Observing time
- Antenna configuration

Basic Simdata Inputs

```
CASA <60>: inp("simdata")
#  simdata :: mosaic simulation task:
project             =       'sim'          #  root for output file names
modifymodel         =       False          #  modify model image
     skymodel       = '$project.skymodel' #   model image to observe or modify

setpointings        =       False
     ptgfile        = '$project.ptg.txt' #   list of pointing positions

predict             =        True          #  calculate visibilites using ptgfile
     complist       =          ''          #  optional componentlist to observe with
                                           #   skymodel
     compwidth      =      '2GHz'          #  optional bandwidth if simulating from
                                           #   components only
     antennalist    =  'alma.out10.cfg'    #  antenna position file or "" for no
                                           #   interferometric MS
     refdate        = '2012/05/21/22:05:00' #  time/date of observation *see help
     totaltime      =     '7200s'          #  total time of observation
```

Parameters that can be changed

Current values of parameters

Explanation of what the parameters are

Basic Simdata Inputs

```
CASA <60>: inp("simdata")
#  simdata :: mosaic simulation task:
project             =       'sim'          #  root for output file names
modifymodel         =       False          #  modify model image
     skymodel       = '$project.skymodel' #  model image to observe or modify

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predict             =        True          #  calculate visibilites using ptgfile
     complist       =          ''          #  optional componentlist to observe with
                                           #   skymodel
     compwidth      =      '2GHz'          #  optional bandwidth if simulating from
                                           #   components only
     antennalist    = 'alma.out10.cfg'     #  antenna position file or "" for no
                                           #   interferometric MS
     refdate        = '2012/05/21/22:05:00' #  time/date of observation *see help
     totaltime      =     '7200s'          #  total time of observation
```

Model Input FITS File

Header must include:

- Coordinates
- Brightness units
- Observing frequency
- Pixel Scale (angular and spectral)
- Polarization (if needed)
- OR: Modify FITS image within Simdata

Change your input file: modifymodel

```
modifymodel            =       True          #  modify model image
     skymodel          = '$project.skymodel' #  model image to observe or modify
     inbright          =         ''          #  set peak surface brightness e.g.
                                             #   "1.2Jy/pixel" or ""
     indirection       =         ''          #  "J2000 19h00m00 -40d00m00" or ""
     incell            =         ''          #  cell/pixel size e.g. "0.1arcsec" or ""
     incenter          =         ''          #  frequency of center channel e.g. "89GHz" or
                                             #   ""
     inwidth           =         ''          #  channel width e.g. "10MHz" or ""
```

- modifymodel = True
- skymodel = “30dor.fits”
- inbright = ”0.1mJy/pixel”
- indirection = "J2000 10:00:00 -40:00:00”
- incell = "0.25arcsec”
- incenter = "230GHz”
- inwidth = '2GHz'

setpointings

```
setpointings          =       True
     integration      =      '10s'          #  integration (sampling) time
     direction        =         ''          #  "J2000 19h00m00 -40d00m00" or "" to center
                                            #   on model
     mapsize          = ['1arcmin', '1arcmin'] #  angular size of map or "" to cover
                                            #   model
     maptype          = 'hexagonal'         #  hexagonal, square, etc
     pointingspacing =  '1arcmin'          #  spacing in between pointings or "" for 0.5
                                            #   PB
```

- integration = '600s’
- mapsize = ””
- pointingspacing = ""

predict

```
predict                =       True          #  calculate visibilites using ptgfile
     complist          =         ''          #  optional componentlist to observe with
                                             #   skymodel
     compwidth         =     '2GHz'          #  optional bandwidth if simulating from
                                             #   components only
     antennalist       = 'alma.out10.cfg'    #  antenna position file or "" for no
                                             #   interferometric MS
     refdate           = '2012/05/21/22:05:00' #  time/date of observation *see help
     totaltime         =    '7200s'          #  total time of observation
     caldirection      =         ''          #  pt source calibrator [experimental]
     calflux           =      '1Jy'
     sdantlist         =         ''          #  single dish antenna position file or "" for
                                             #   no total power MS
     sdant             =          0          #  single dish antenna index in file
```

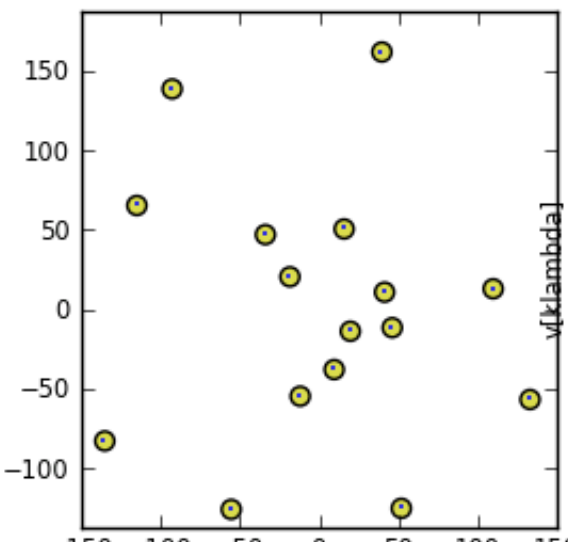
- repodir = os.getenv("CASAPATH").split(' ')[0]
- antennalist = repodir+"/data/alma/simmos/alma.early.250m.cfg"

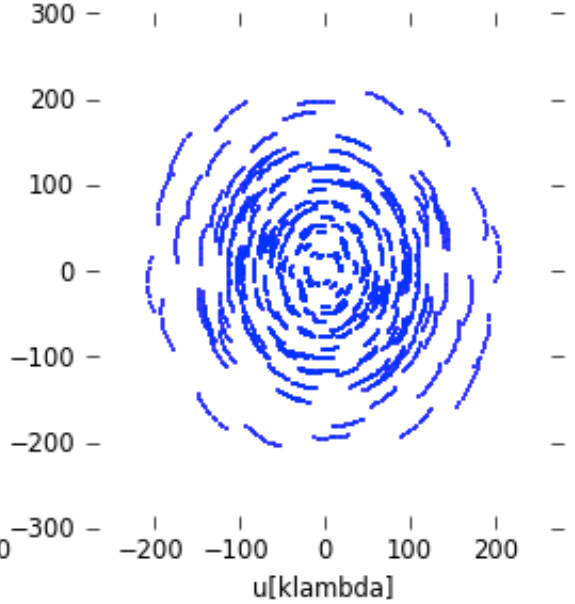
Simdata Output

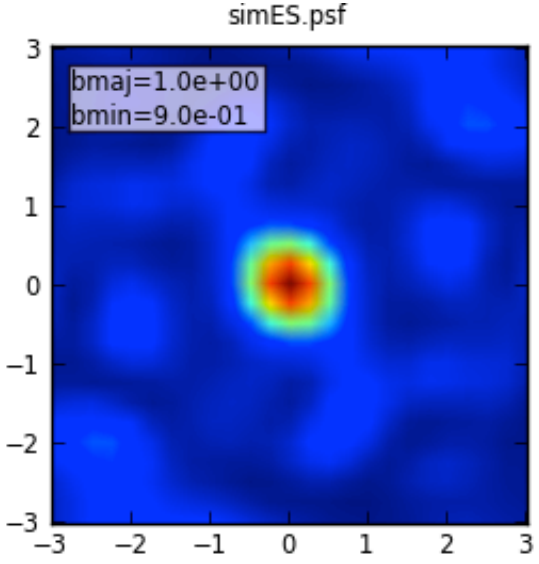
```
analyze            =         True       #  (only first 6 selected outputs will be
                                        #   displayed)
     showarray     =        False       #  like plotants
     showuv        =         True       #  display uv coverage
     showpsf       =         True       #  display synthesized (dirty) beam
     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
     showdifference =         True      #  display difference image
     showfidelity  =         True       #  display fidelity
```

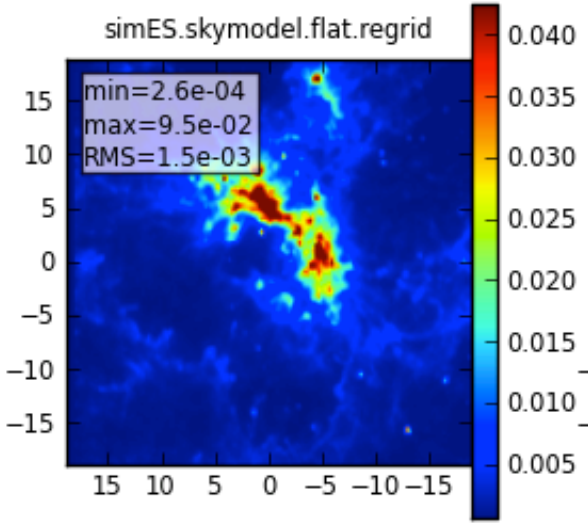
- analyze = True
- showarray = True
- showconvolved = True
- showdifference = False
- showfidelity = False

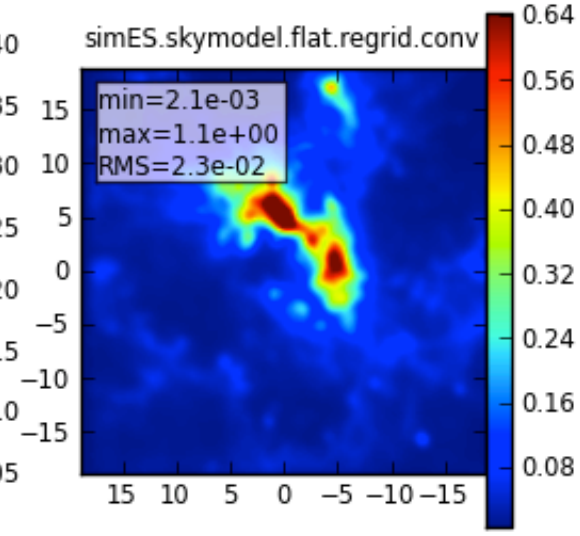
Simdata Output

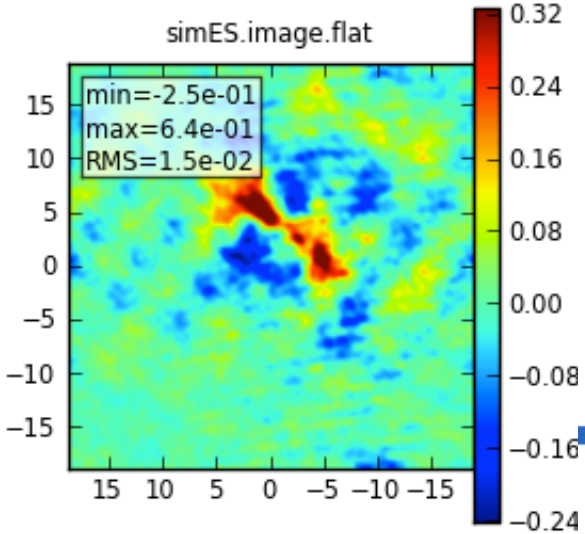




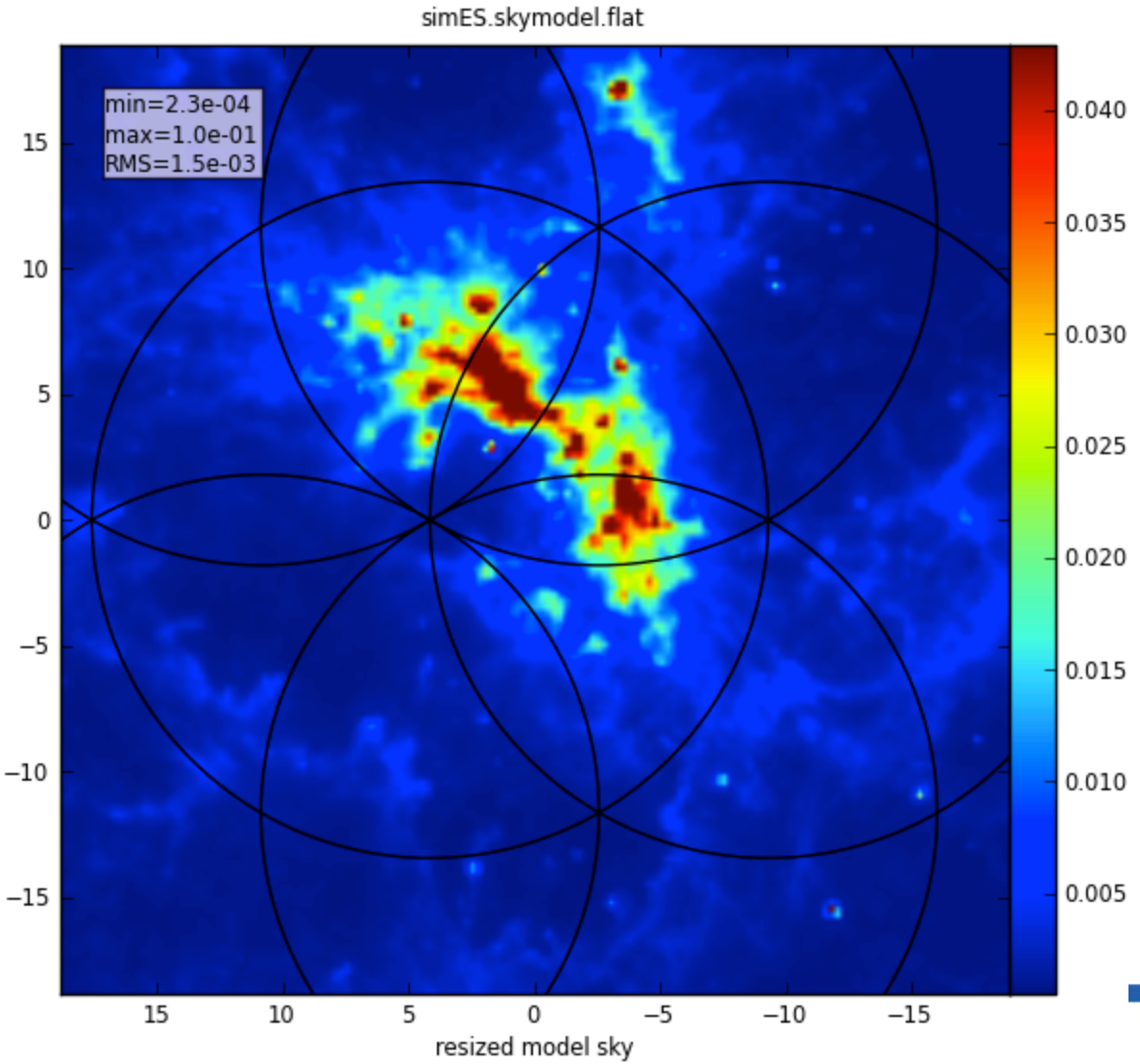






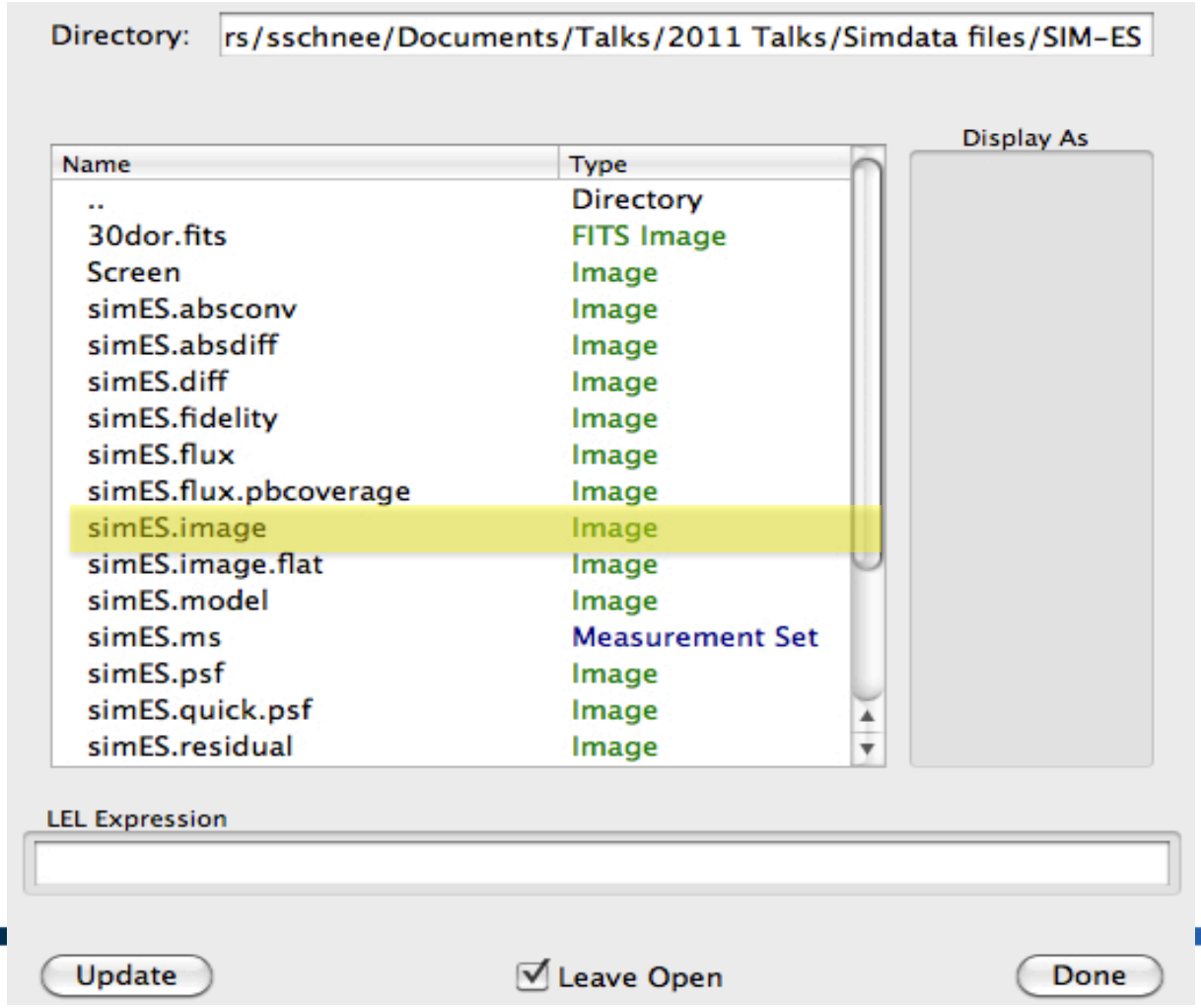


Simdata Output



Simdata Output – Viewer

http://casa.nrao.edu/CasaViewerDemo/casaViewerDemo.html



Other Simdata Options
Thermal Noise

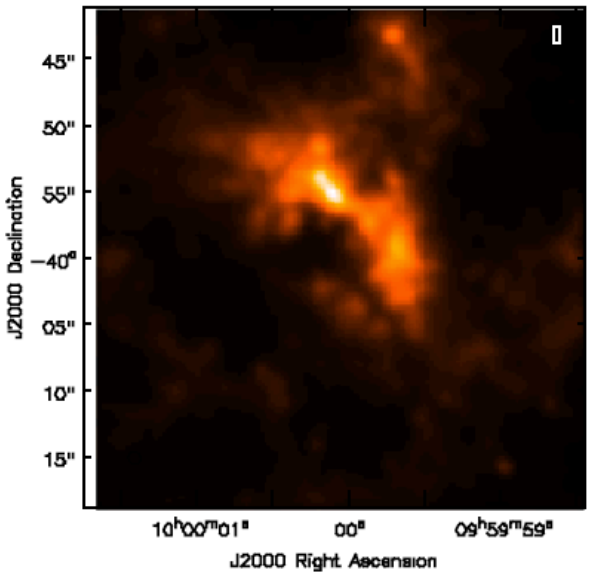
```
thermalnoise          = 'tsys-atm'          #  add thermal noise: [tsys-atm|tsys-
                                            #   manual|""]
     user_pwv         =          1.0        #  Precipitable Water Vapor in mm
     t_ground         =        270.0        #  ambient temperature

leakage               =          0.0        #  cross polarization
image                 =         True        #  (re)image $project.ms to
                                            #   $project.image
     vis              = '$project.noisy.ms' #  Measurement Set(s) to image
```

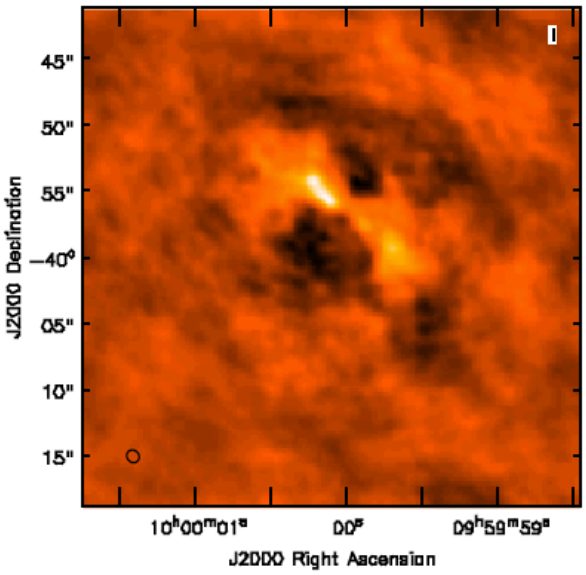
- thermalnoise = 'tsys-atm'
- image = True
- vis='$project.noisy.ms'

Other Simdata Options
Thermal Noise

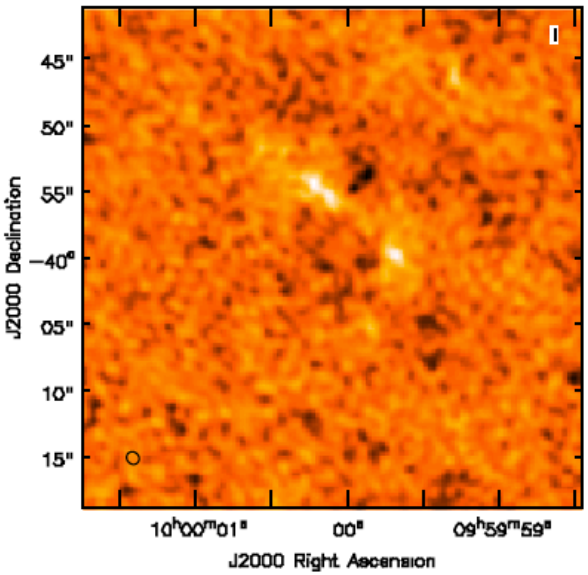
Convolved Model



No Thermal Noise



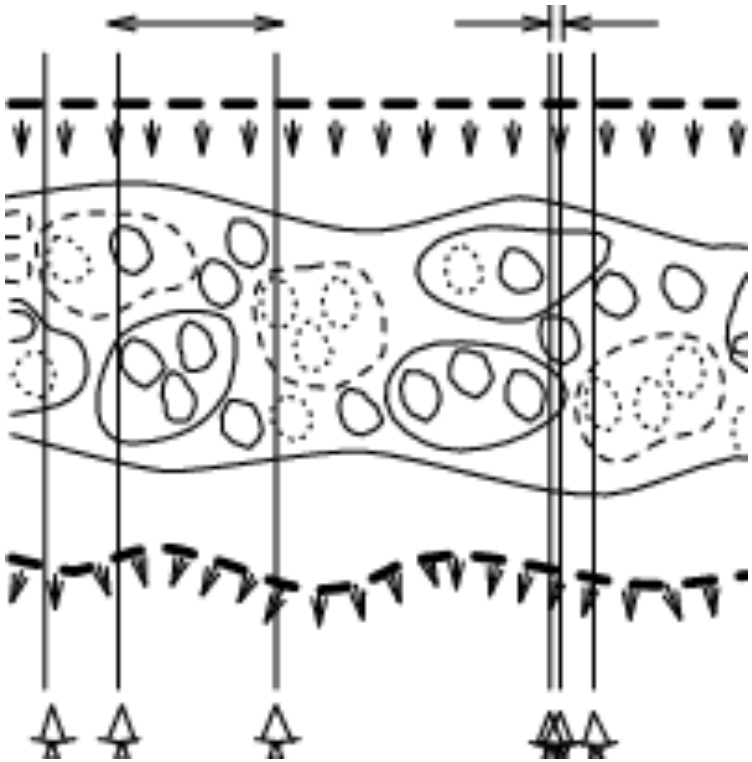
Thermal Noise



Atmospheric phase fluctuations

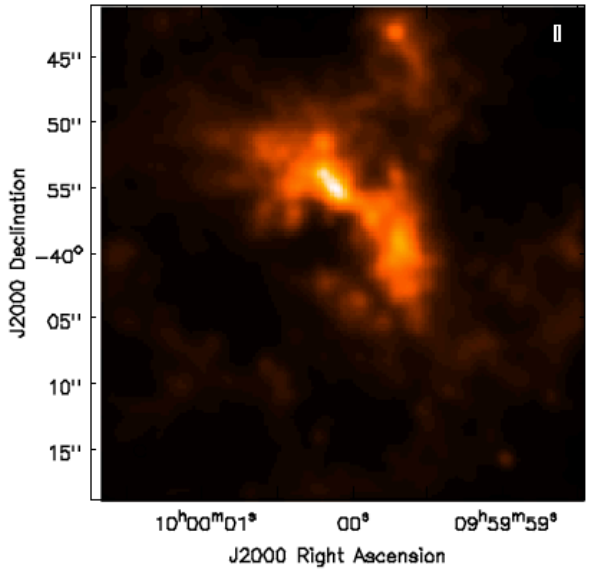
- Variations in the amount of precipitable water vapor (PWV) cause phase fluctuations and result in
  - Low coherence (loss of sensitivity)
  - Radio "seeing", typically 1″ at 1 mm
  - Anomalous pointing offsets
  - Anomalous delay offsets

Patches of air with different water vapor content (and hence index of refraction) affect the incoming wave front differently.

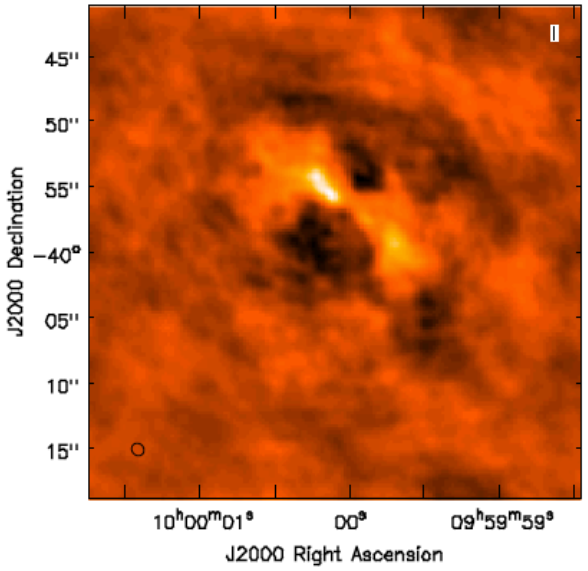


Other Simdata Options
Phase Noise

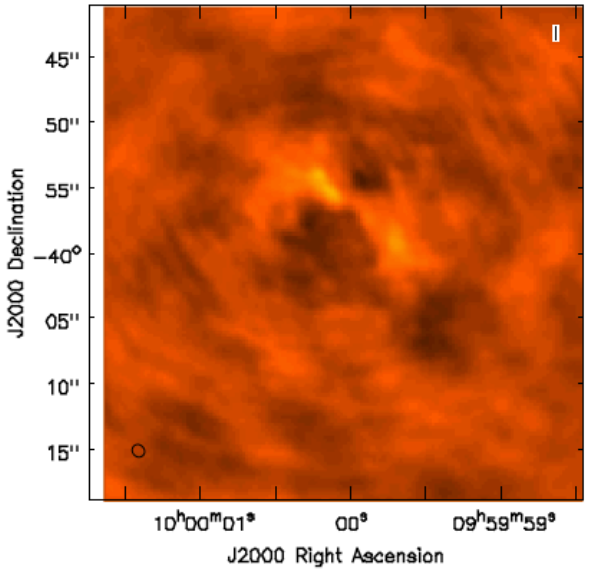
Convolved Model



No Phase Noise



Phase Noise



Other Simdata Options
Phase Noise

- Start with the visibilities (measurement set) created by simdata
- Use the "toolkit" to add phase noise
  - http://casa.nrao.edu/docs/CasaRef/CasaRef.html
  - http://casaguides.nrao.edu/index.php?title=Corrupt
  - sm.openfromms("simPN.ms")
  - sm.settrop(mode='screen',pwv=1.0,deltapwv=0.15)
  - sm.corrupt()
  - sm.done()
- Use `clean` (in CASA) to make the image

Your Turn

- Find a fits file of an object you want to image
- Use simdata to see how it would look if observed with ALMA
  - Rescale image if necessary
  - Try different antenna configurations
  - Add noise if interested
- Don't be afraid to ask for help!

Your Turn

- Sample images can be found at:
  - http://casaguides.nrao.edu/index.php?title=Sim_Inputs
- Simdata walk-throughs available at:
  - http://casaguides.nrao.edu
    - Simulating observations in CASA 3.1