End-to-end workflow from searching for data to producing a science-grade image

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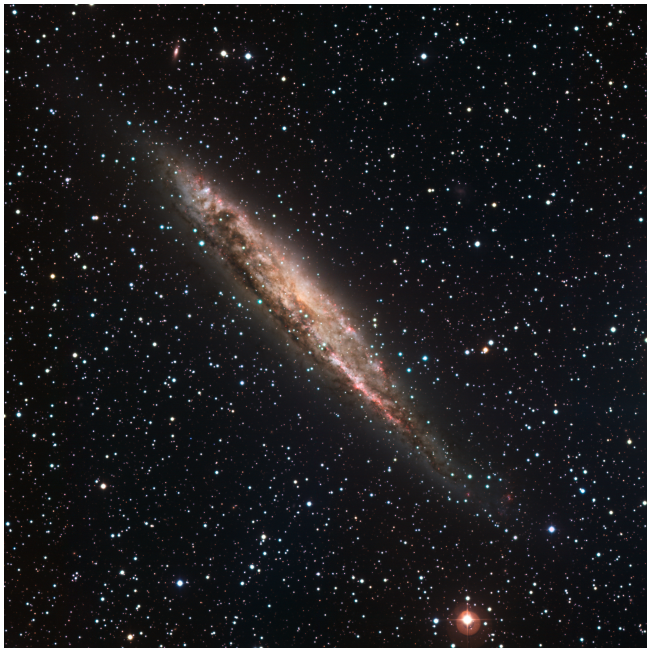
Find your target in the archive

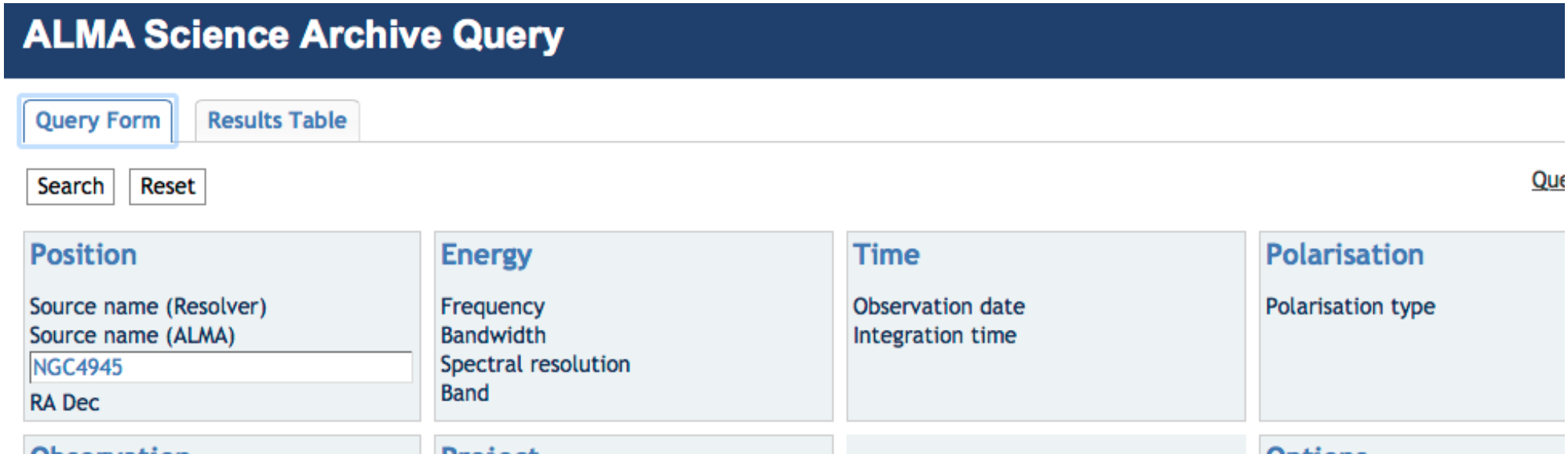
Nearby starburst galaxy NGC 4945

Has been observed with Herschel/HIFI

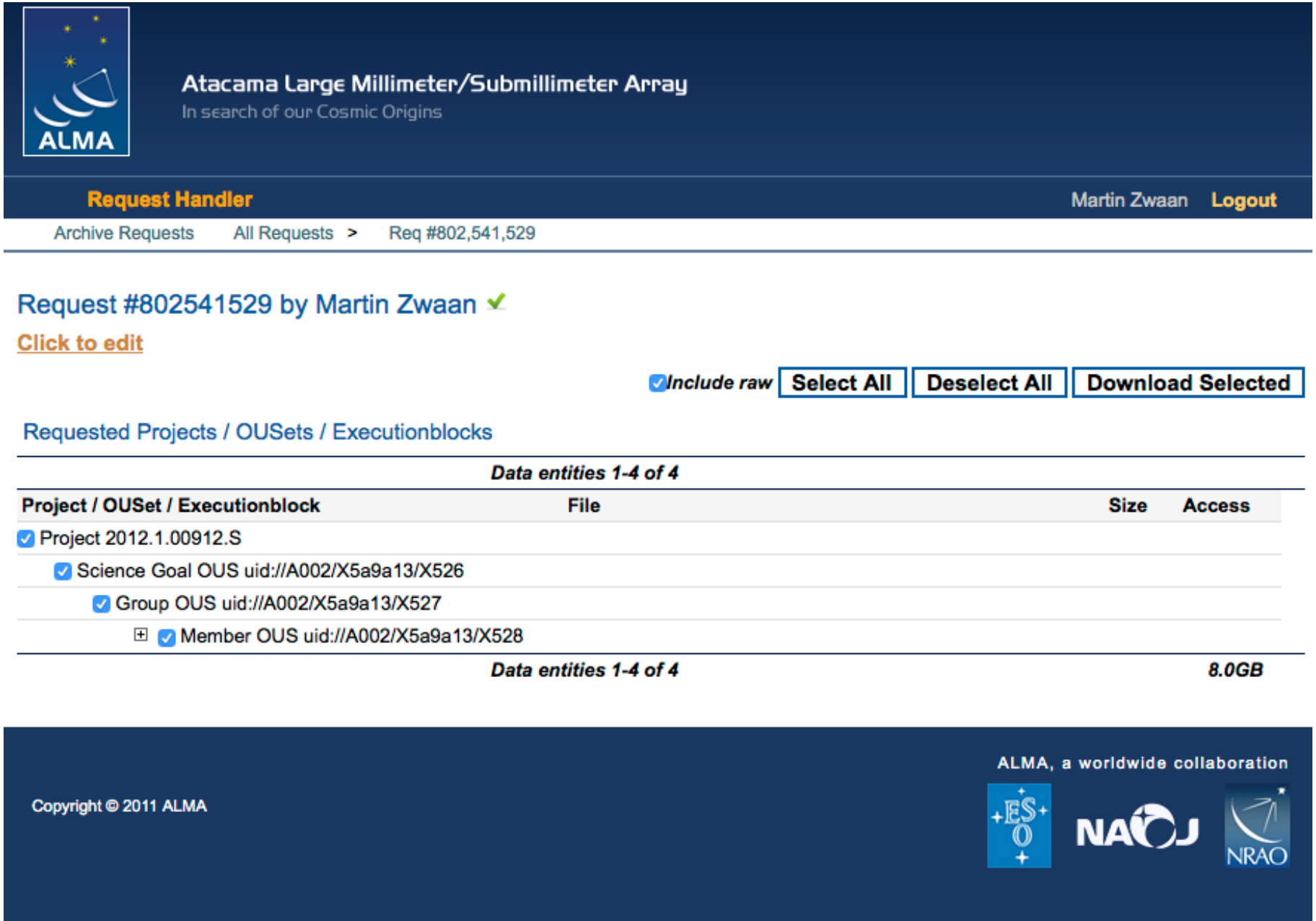
Our goal is to find its data in the ALMA archive…

…and make better images





Find the data...

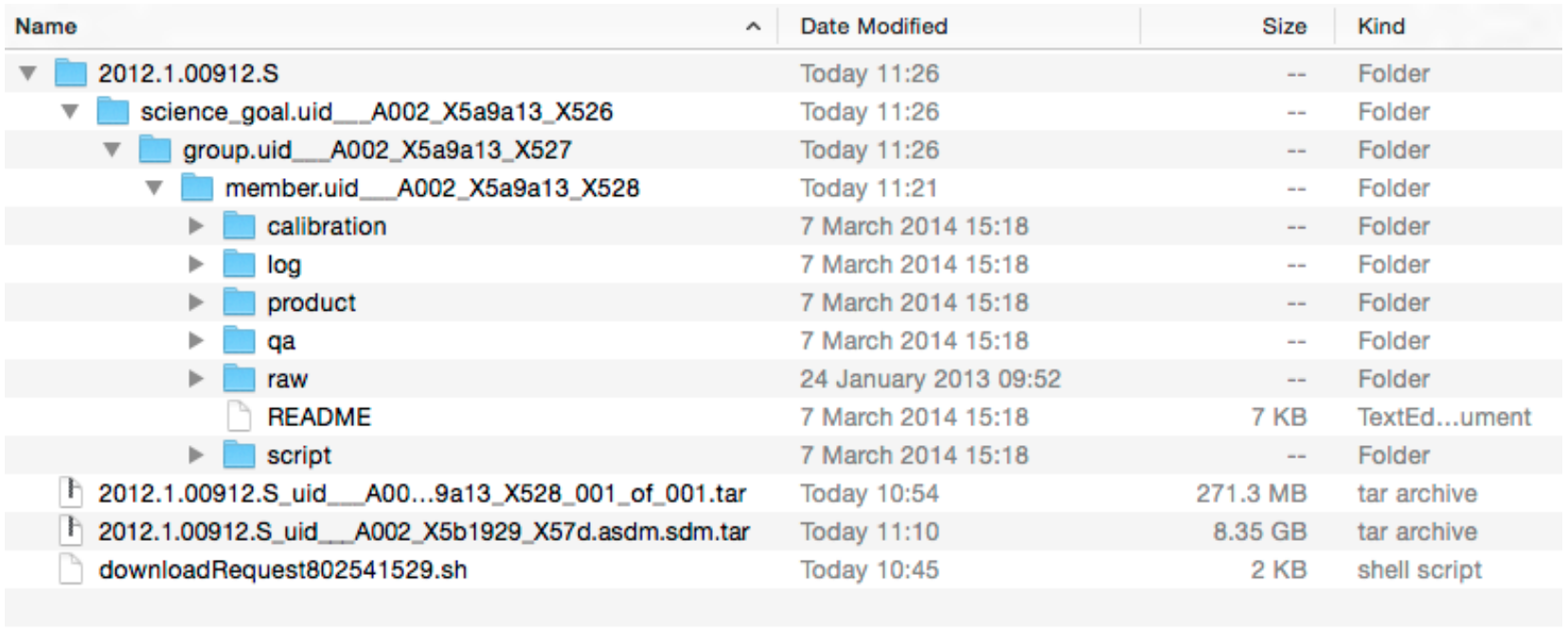


Find out what is in the package

Download the package:
2012.1.00912.S_uid___A002_X5a9a13_X528_001_of_001.tar

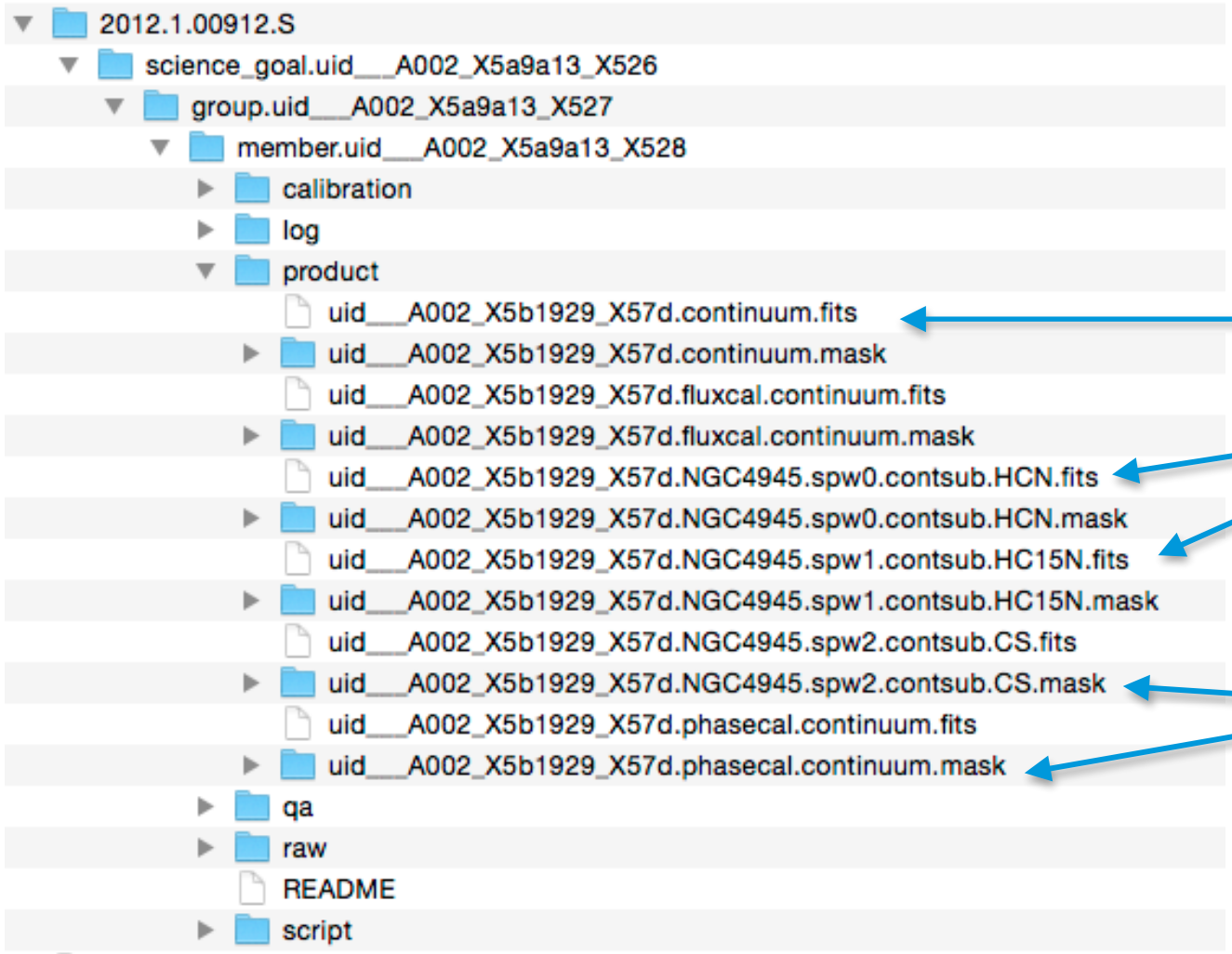
and download the raw data as well:
2012.1.00912.S_uid___A002_X5b1929_X57d.asdm.sdm.tar

untar the lot



Where are the images/cubes?

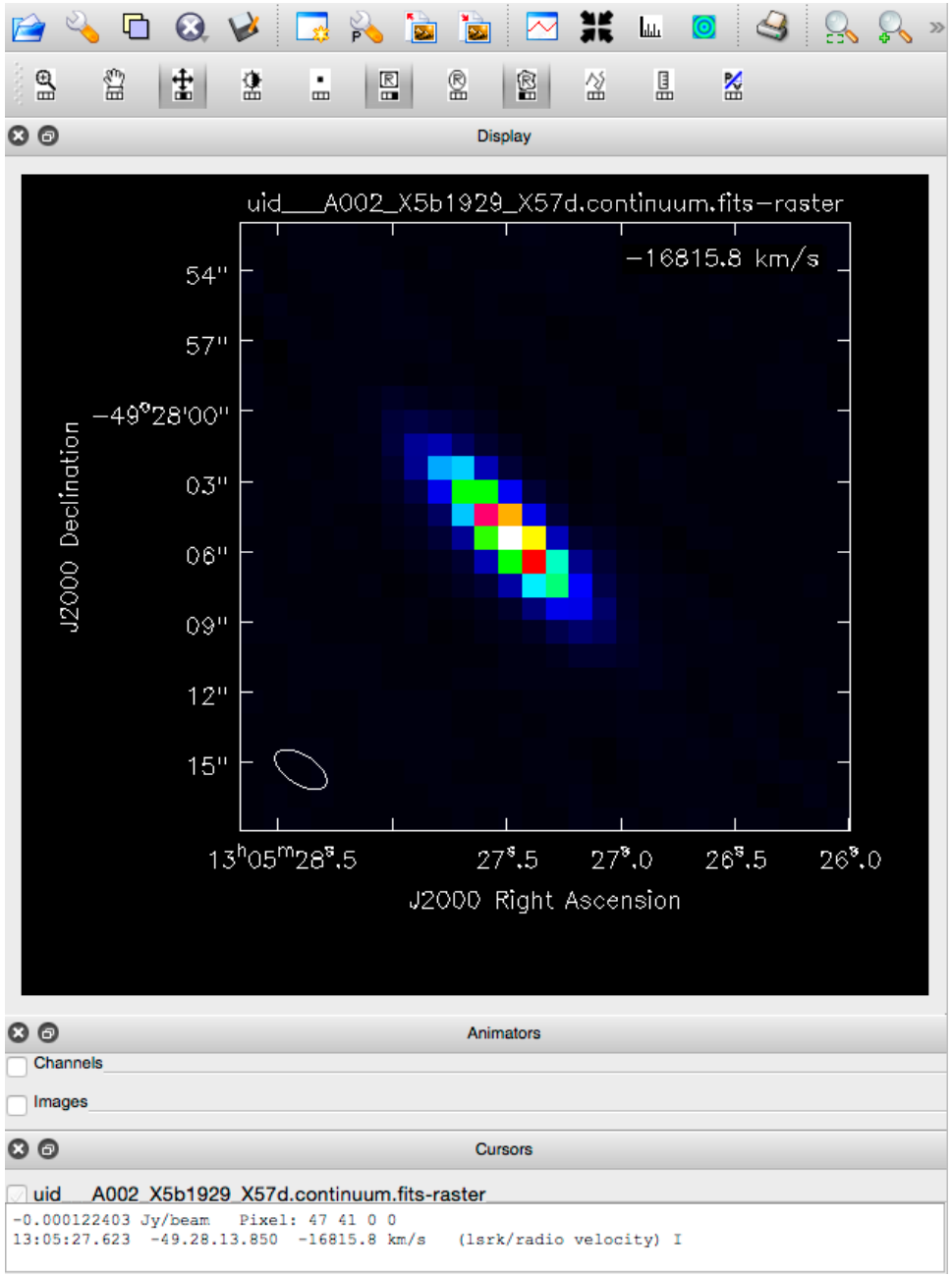
Inside the directory ‘products’, you can find FITS images and cubes



What do the images and cubes look like?

Inside casa, use ‘imview’ to display the image or cube

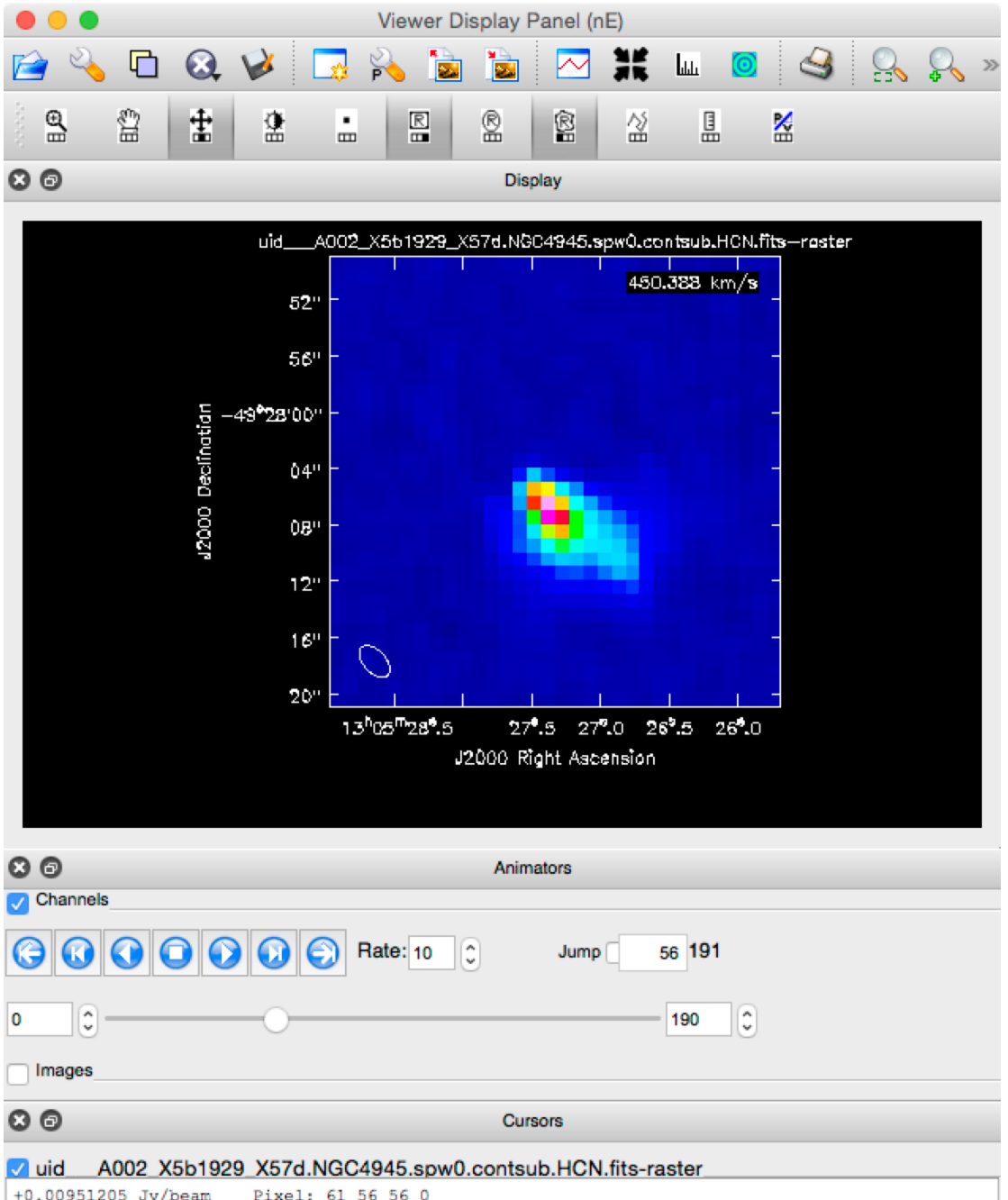
```
imview('uidxxx.continuum.fits')
```



What do the images and cubes look like?

Inside casa, use ‘imview’ to display the image or cube

```
imview('uidxxx.HCN.fits')
```



But I want other images…

The standard package will contain **a continuum image**, and some **cubes of lines** that were mentioned in the proposal

Perhaps you want more:

- **Better deconvolution** (more careful definition of clean boxes)
- **Self-calibration** to enhance the image dynamic range
- Make cubes of **other spectral lines**
- Something else

If you want to re-image:
you have to **recreate the calibrated measurement set.**
(Note: for Cycle 0 data, this ms is contained within the package)

Rerun the calibration script

in directory ‘script’, start up casa and execute ‘scriptForPI.py’

```
> execfile('scriptForPI.py')
```

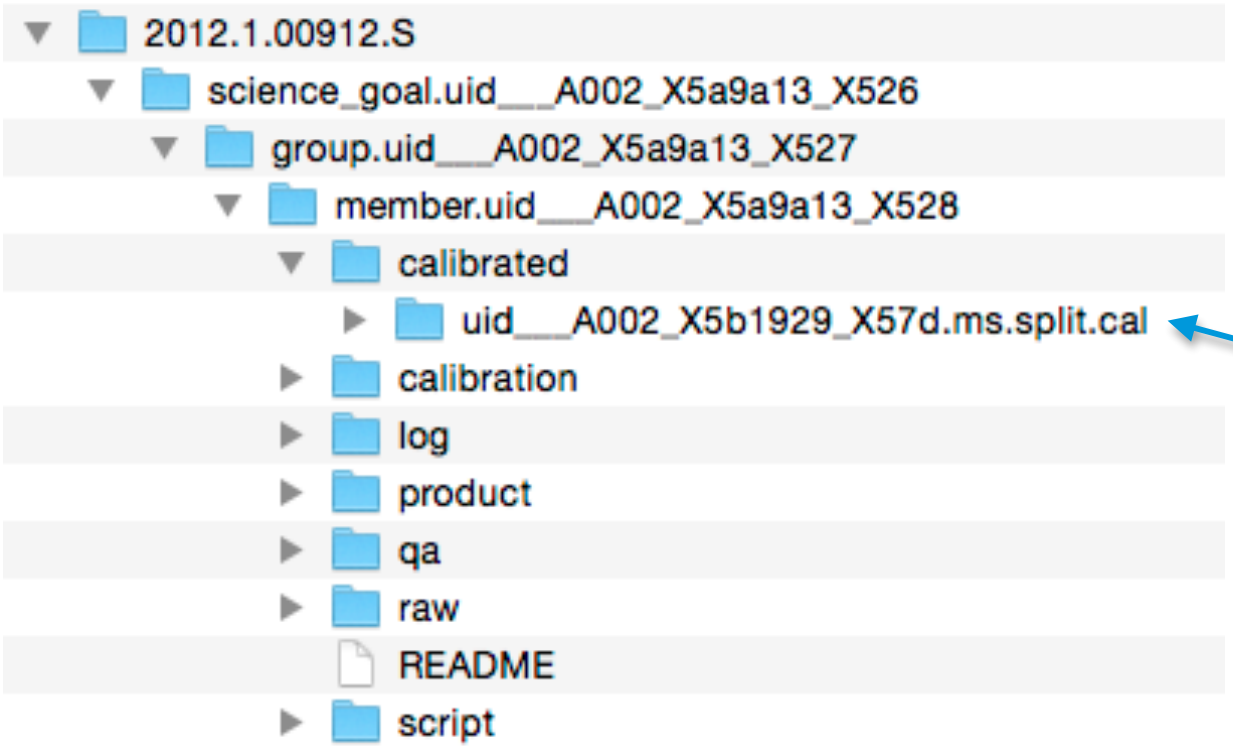
This will **execute the tailored calibration script**.
(apply flagging, do different kinds of calibration:
T_{sys}, wvr, bandpass, phase, and flux scale)

Note: This runs for one or two hours.
Needs a lot of space! (at least 100 Gb)

The **result is a fully calibrated measurement set**, inside the directory ‘calibrated’

Now, you are ready to make more images and cubes

After running the calibration script



Fully calibrated measurement set. Ready for imaging!

How to make images

For interferometry data, imaging entails two important steps:

1. Fourier transform

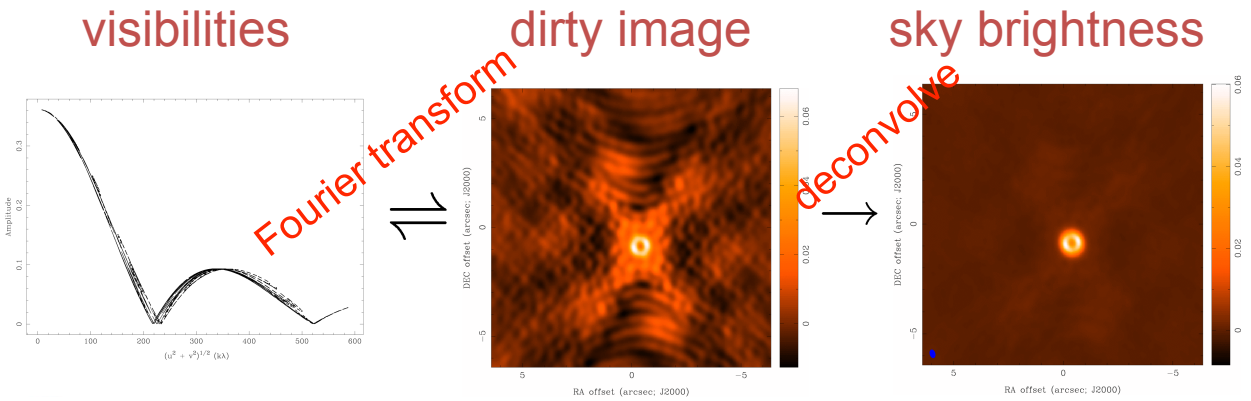
The interference pattern is directly related to the source brightness. The complex visibility, V(u,v), is the 2D Fourier transform of the brightness on the sky, T(x,y)

$$V(u,v) = \int\int T(x,y) e^{2\pi i(ux+vy)} dxdy$$

$$T(x,y) = \int\int V(u,v) e^{-2\pi i(ux+vy)} dudv$$

2. Deconvolution

Unfilled aperture: Incomplete sampling of uv plane: sidelobes



Imaging in CASA

This is done with the task '**clean**'.

This task does **both the Fourier transform and the deconvolution** in a nested way

It can be done **interactively** or **'blind'**

One can choose

- frequency range
- continuum or cubes
- width of output channels
- weighting scheme (enhance resolution vs enhance sensitivity)
- tapering of the data
- image size
- and many more advanced options…

Deconvolution with CLEAN

The most common method for deconvolving ALMA maps is **CLEAN**

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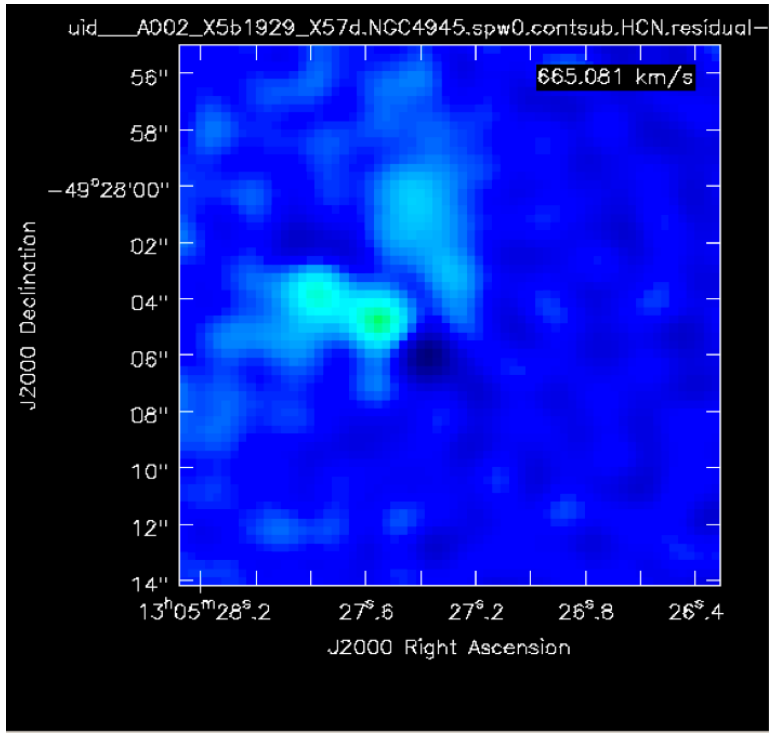

Find highest peaks in image

Deconvolution with CLEAN

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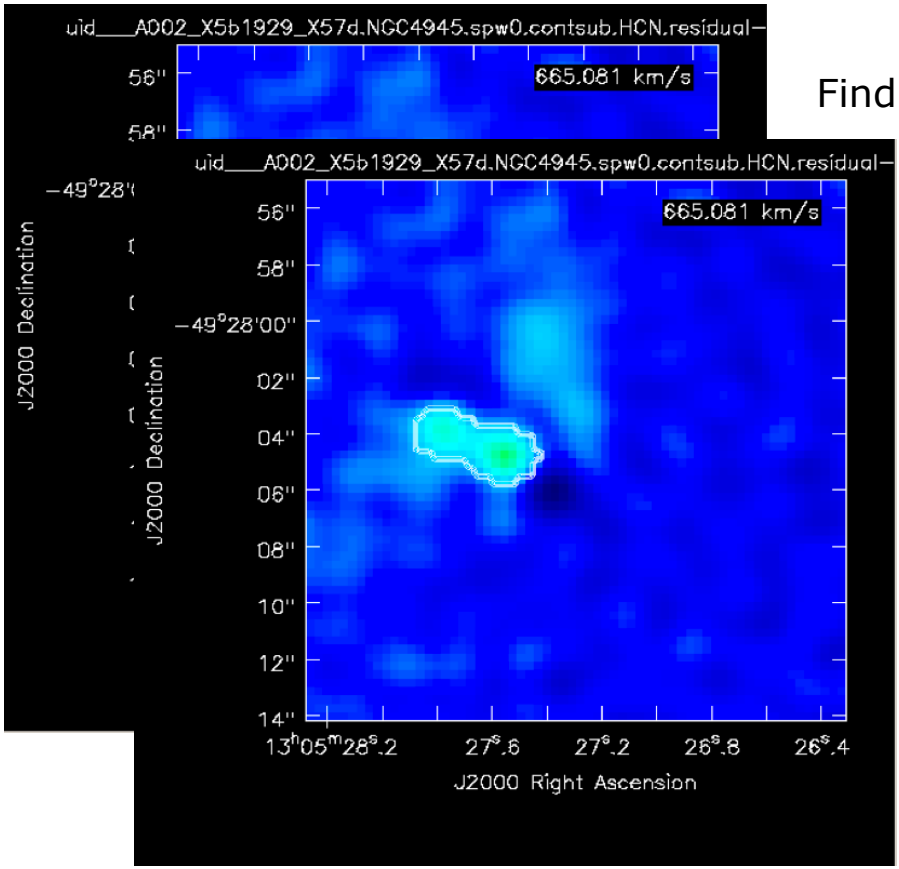

Find highest peaks in image

Constrain where to look for peaks: MASK

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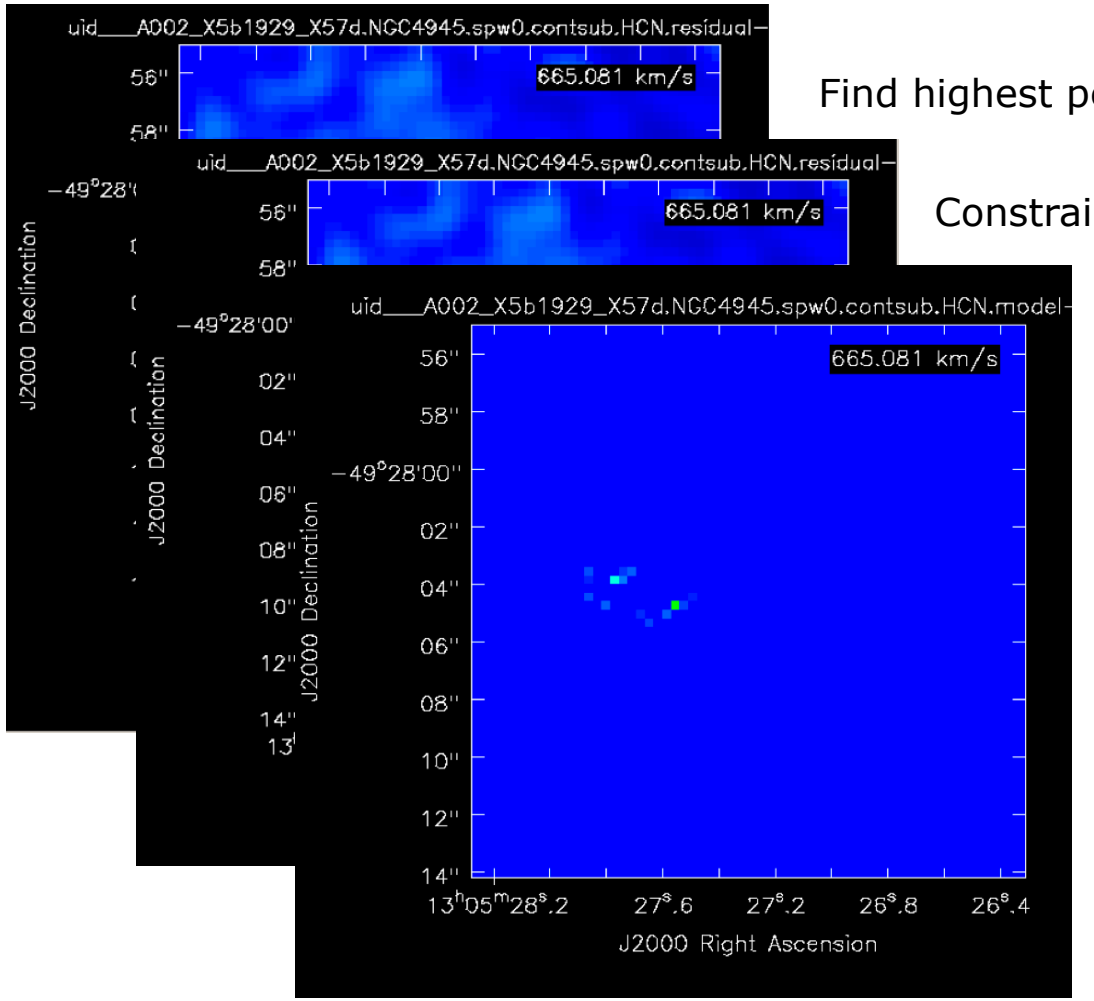

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Build point source model

Deconvolution with CLEAN

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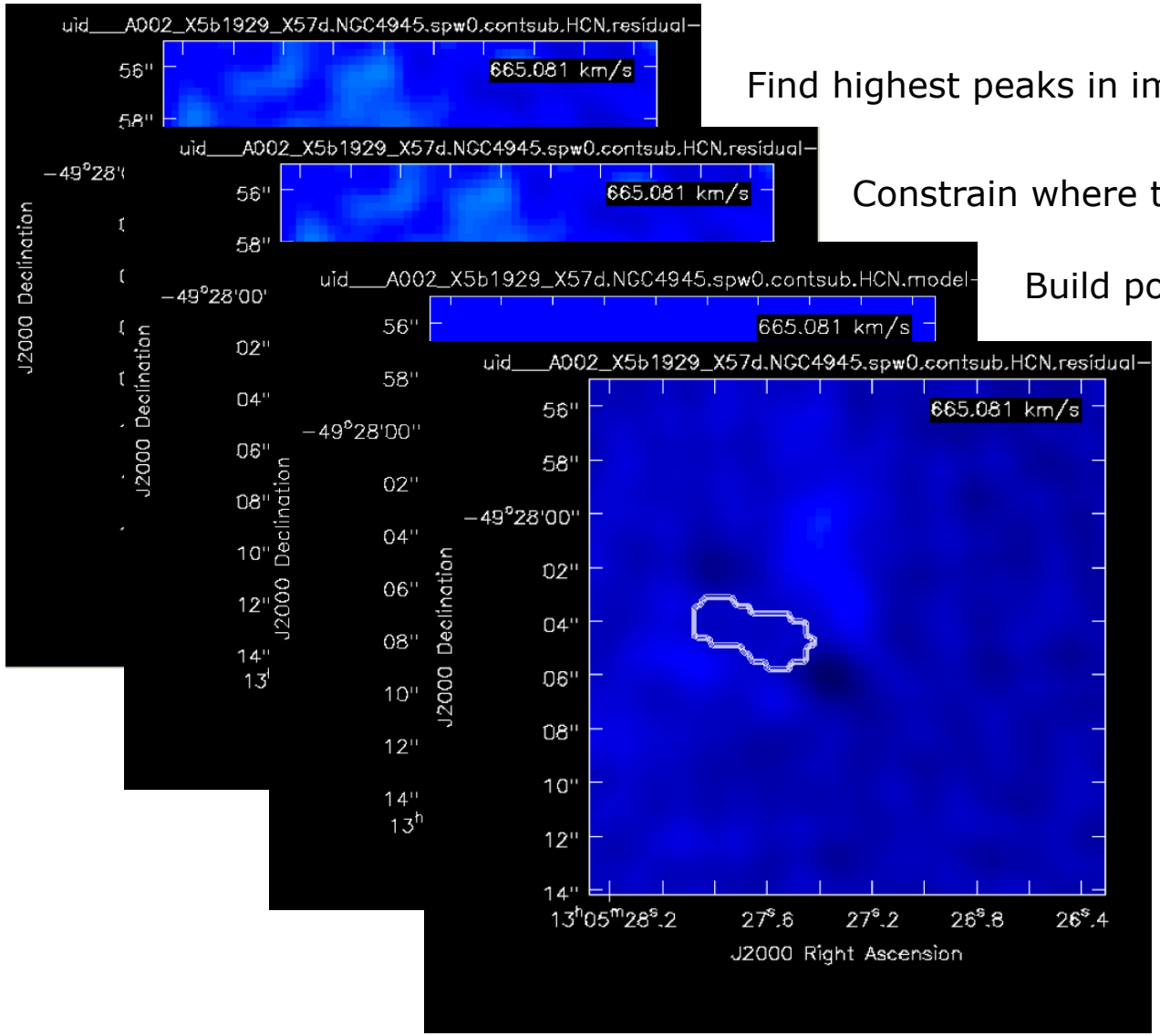

Find highest peaks in image

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Build point source model

Subtract model from the data

Deconvolution with CLEAN

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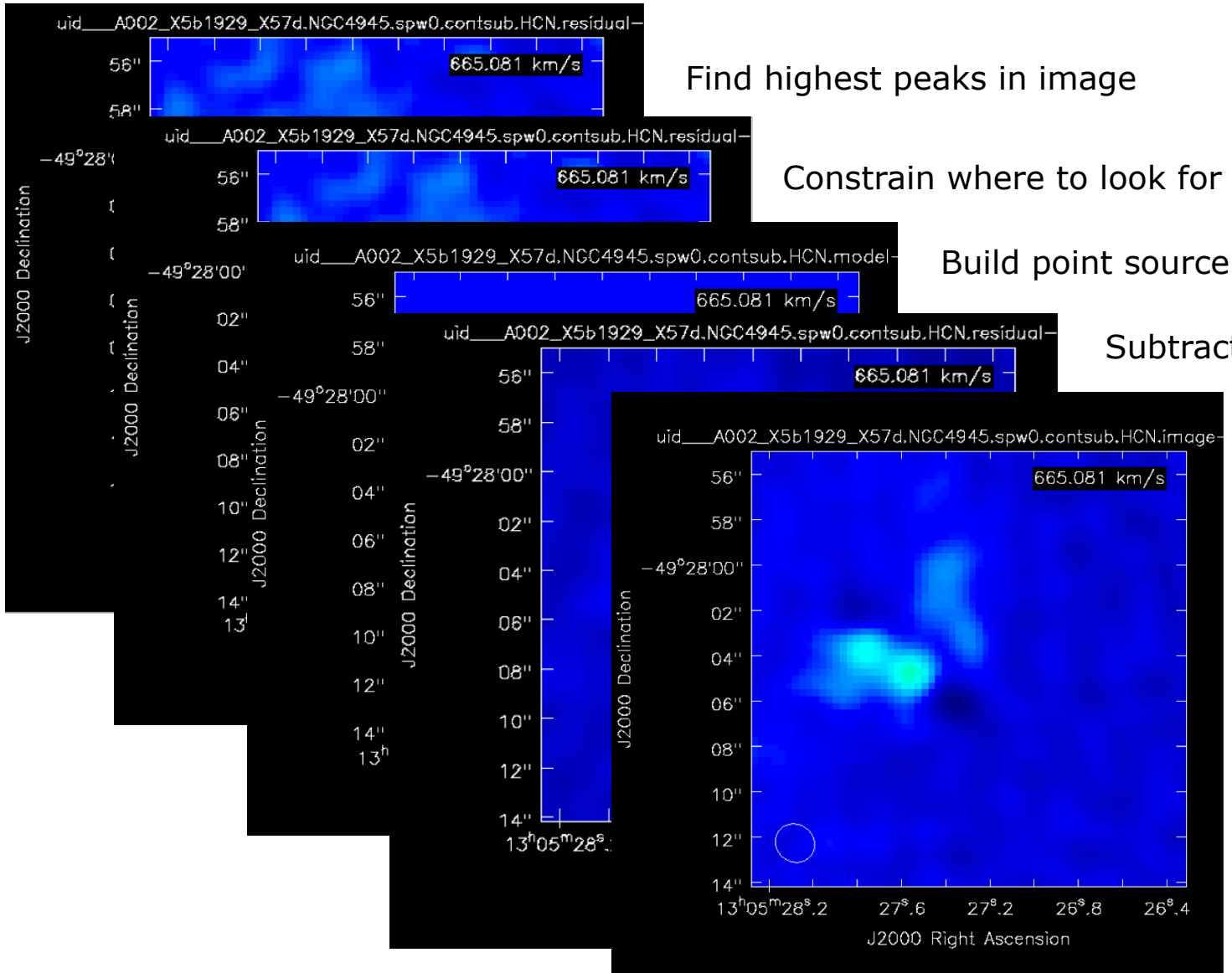

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Build point source model

Subtract model from the data

Convolve model with 'clean' beam and put back in image

Deconvolution with CLEAN

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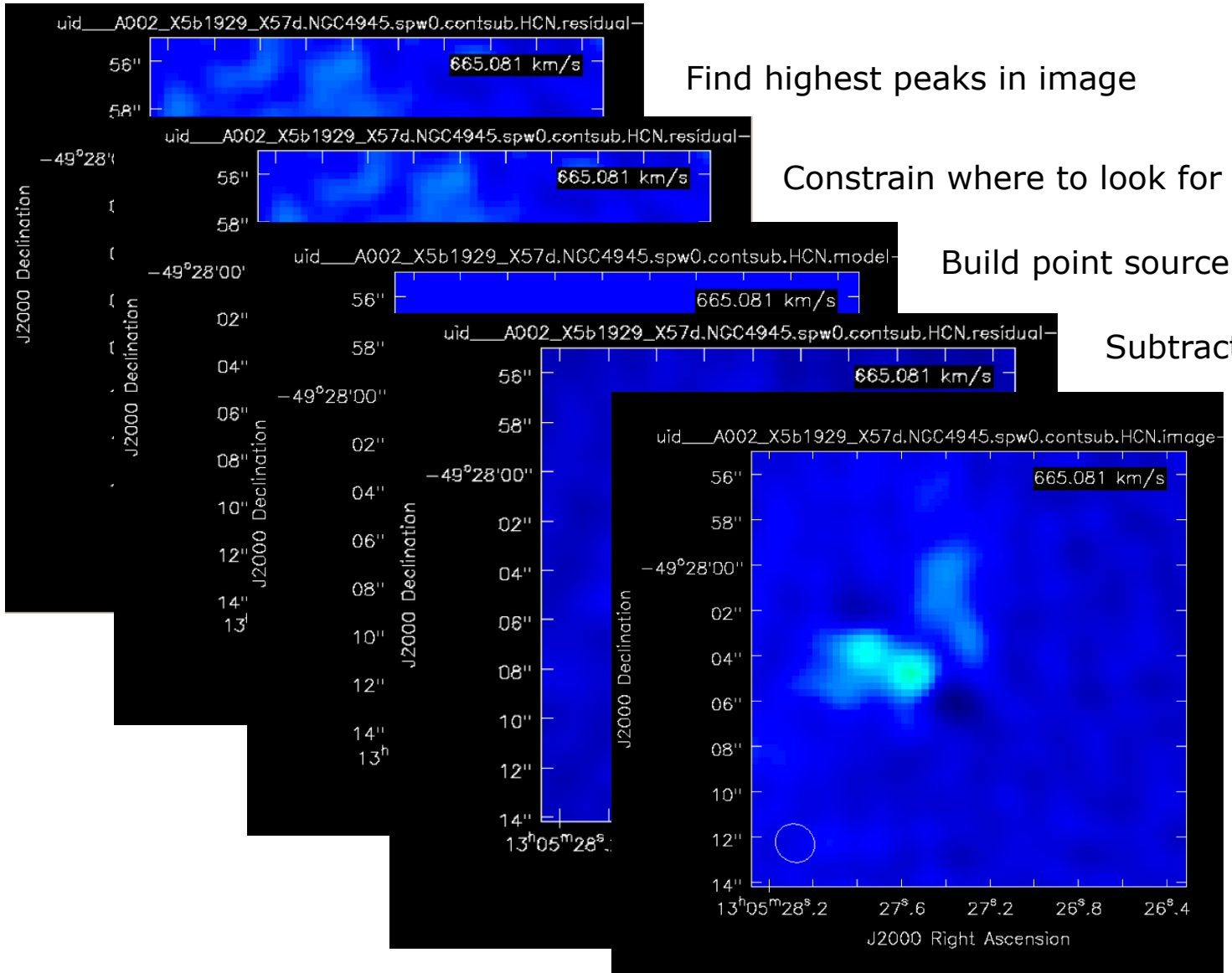

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Build point source model

Subtract model from the data

Convolve model with 'clean' beam and put back in image

Go back to start

First step at making images

First try:
use the script that comes with the package: scriptForImaging.py

in directory ‘calibration’, run

```
>execfile(‘scriptForImaging.py’)
```

This will reproduce the imaging products (FITS) that were contained in the package

It will normally produce continuum maps and line cubes, and will deconvolve using the mask files

Example: remake the continuum image

Use the script that comes with the package: scriptForImaging.py
but **edit** the part where the **continuum image** is made

```
clean(vis='uid___blabla.ms.split.cal',
    imagename='mycontinuum',
    field='3',
    spw='0:20~180;350~460,1:60~80;120~180,2:20~400;700~940,3:80~110',
    mode='mfs',
    niter=500,
    imsize=100,
    cell='1arcsec',
    weighting='briggs',
    robust=0.0,
    interactive=True,
    usescratch=False,
    outframe='BARY')
```

All the channels that contain no line emission

multi-frequency synthesis = continuum

clean iterations

image size

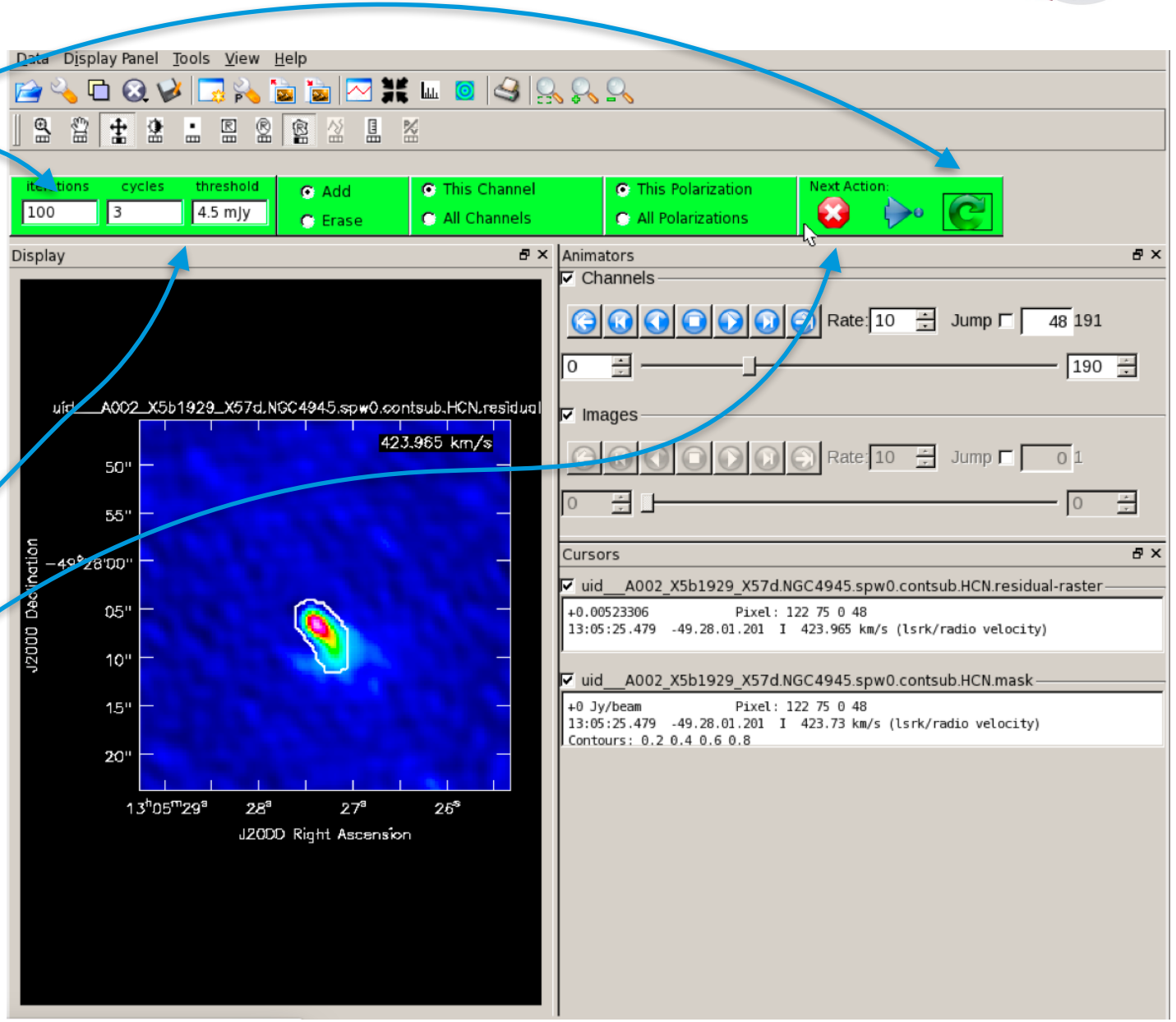
pixel size

Interactive cleaning of the map

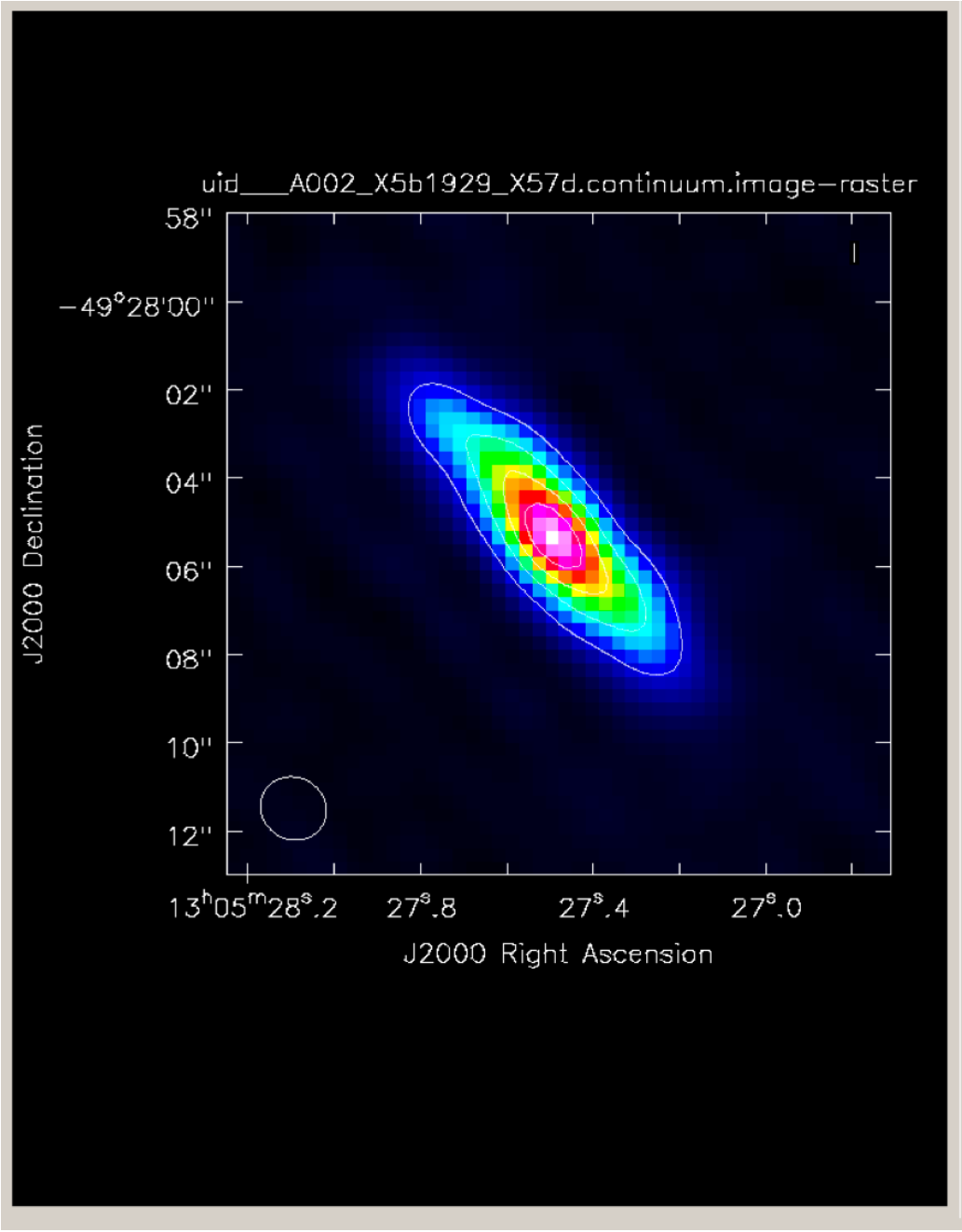
Perform N iterations

and return - every time the residual is displayed is a major cycle

continue until # cycles or threshold reached or user stop

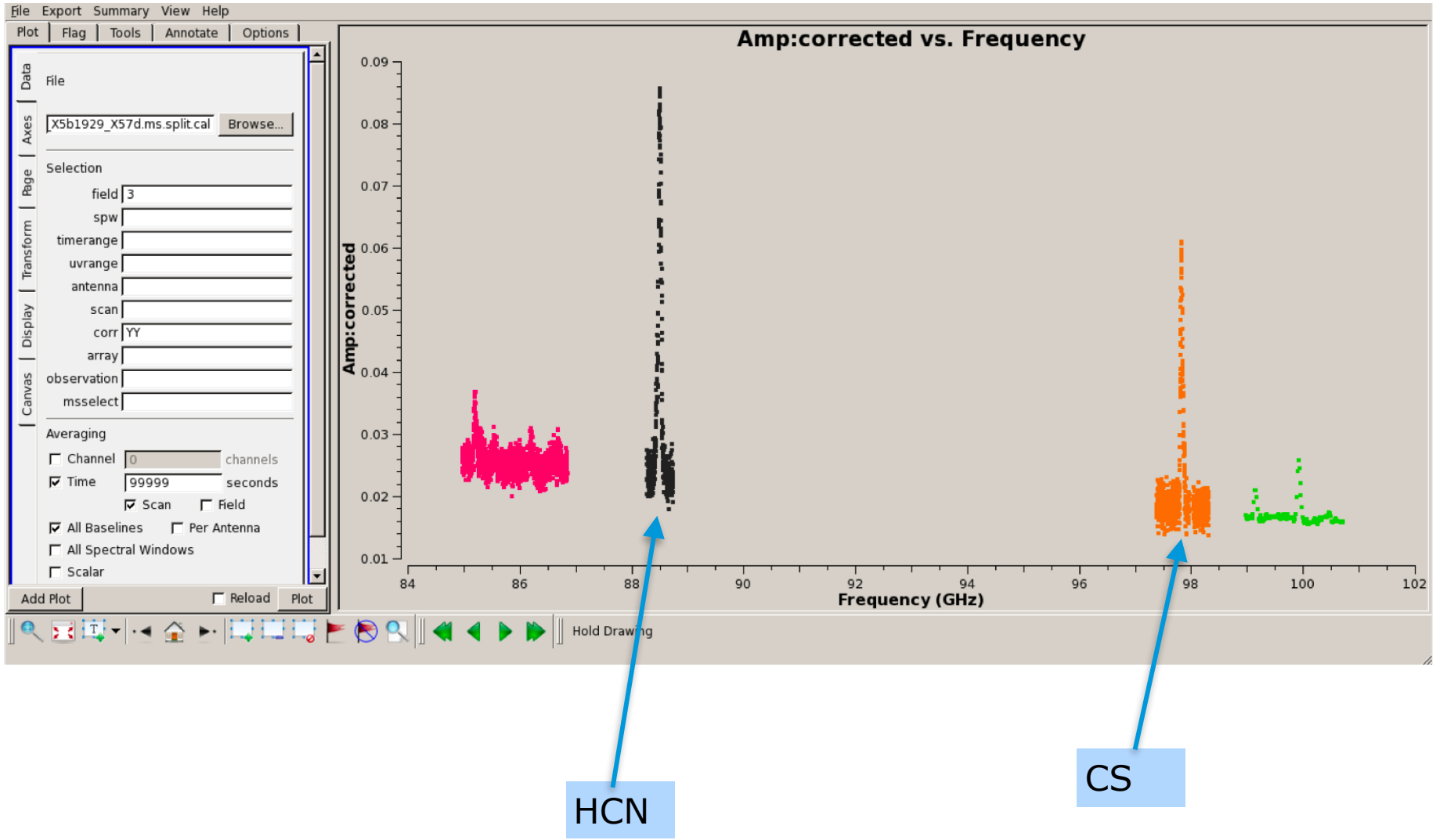


Example: your new continuum image



Make cube of your favourite line emission

First inspect your data. What frequency range is covered? Which lines have been observed? Use CASA task 'plotms'



Make cube of your favourite line emission

Use the script that comes with the package: scriptForImaging.py
but **edit** the part where the **line cube** is made

```
clean( vis='uid___blabla.ms.split.cal',
    imagename='mycube.HCN',
    field='0', # target
    outframe='BARY',
    spw='0', start=170, nchan=191, width=1,
    restfreq='88.63160GHz',
    selectdata=T,
    mode='channel',
    niter=300, gain=0.1,
    mask=[51,50,76,71],
    interactive=True,
    imsize=128,
    cell='1arcsec',
    weighting='briggs', robust=0.0,
    threshold='4.5mJy',
    usescratch=False)
```

Select the channels to image

Rest frequency of the HCN line

Make cube 'per channel'

First guess at a mask

Make new images from ALMA archive data

- Deconvolution uses non-linear techniques
- Synthesis imaging: it is easy to make an image, but not easy to know if your image is right!
- Need help? Use the ALMA Helpdesk or visit one of the European ARC nodes for face-to-face help!