Before you propose...

EUROPEAN ARC
ALMA Regional Centre || Italian

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Cycle 4 Proposal Preparation Day

Proposer Checklist

- Register on the SP
- Write the science case
- Check the following requested parameters
    - Coordinates, proper motion(for nearby sources), ephemeris (for SSO)
    - Angular Resolution
    - Largest Angular Structure
    - Mapping area (for mosaics)
    - Sensitivity
    - Dynamic range
    - Spectral resolution
- Verify the proposal strategy

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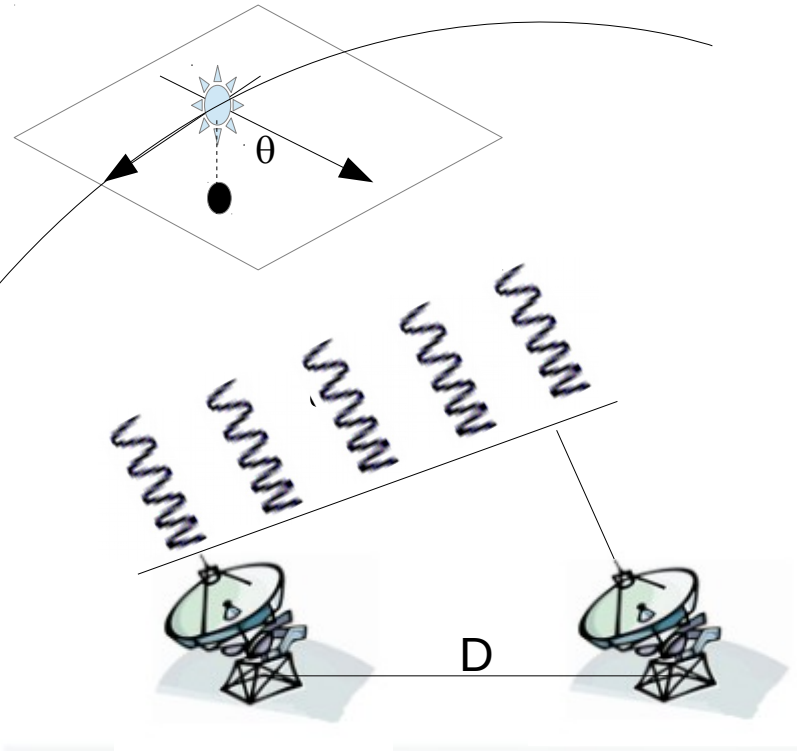
Angular scales

An interferometer reconstructs an image of the sky at fixed spatial scales corresponding to the projection of the distances among each couple of antennas (=baselines) on a plane centered in the target position.

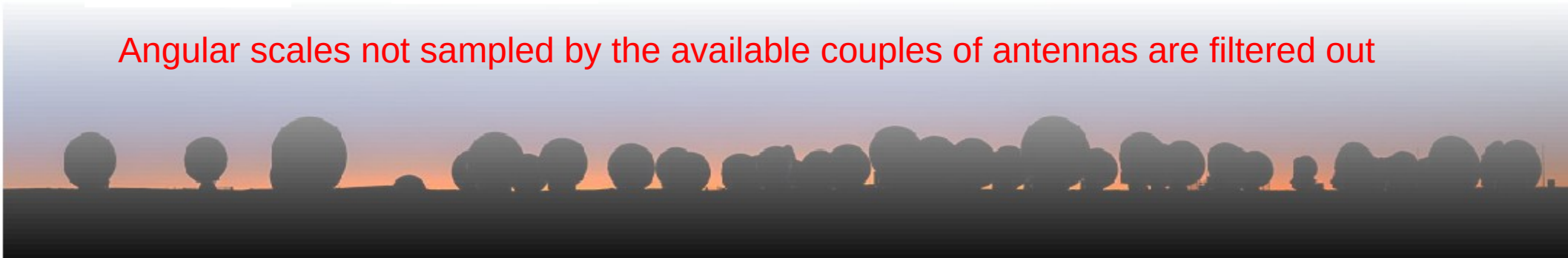


$$\theta \propto \lambda / D$$

Angular scale ∝ Wavelength / Physical scale

Field of View	**Antenna Diameter**
Angular Resolution	**Longest Baseline**
Maximum Recoverable Scale	**Shortest Baseline**

Angular scales not sampled by the available couples of antennas are filtered out

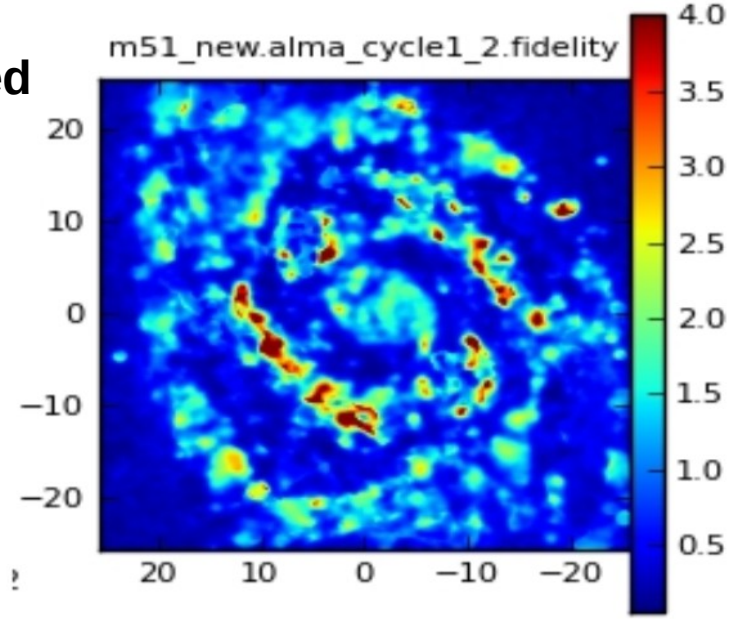


Angular scales in the OT

Resolution **is the minimum angular separation whereby adjacent spatial features can be distinguished depends on the longest baseline baseline**

Largest Angular Structure **is the largest angular scale structure of the source that is of interest for the observations**

Maximum Recoverable Scale **is the maximum angular scale structure that can be recovered depends on the shortest baseline Bmin**

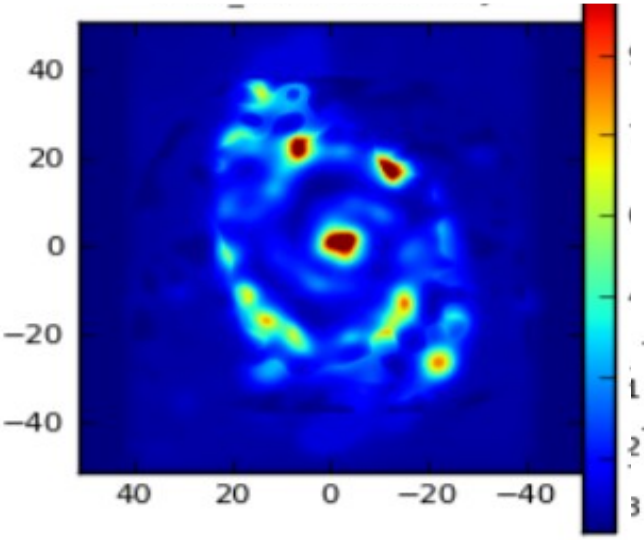


By setting them the OT selects the best antenna configuration.

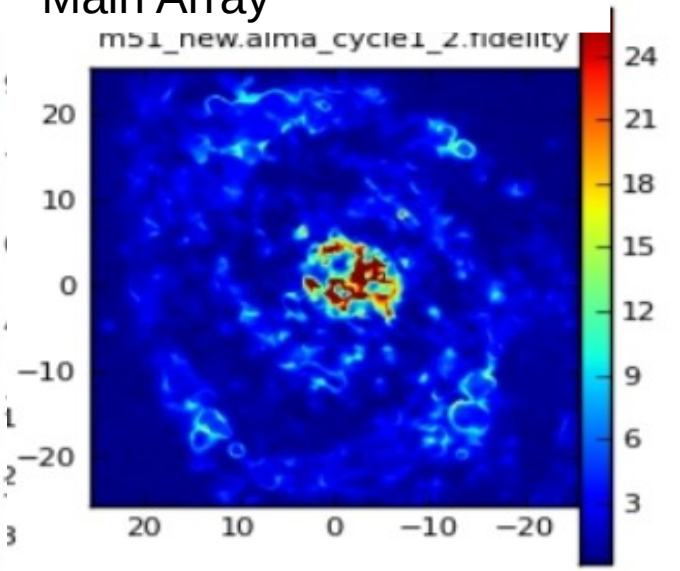
If you select high resolution you lose in large scales and viceversa.

Scales larger than the LAS are filtered out → flux is lost

ACA



Main Array

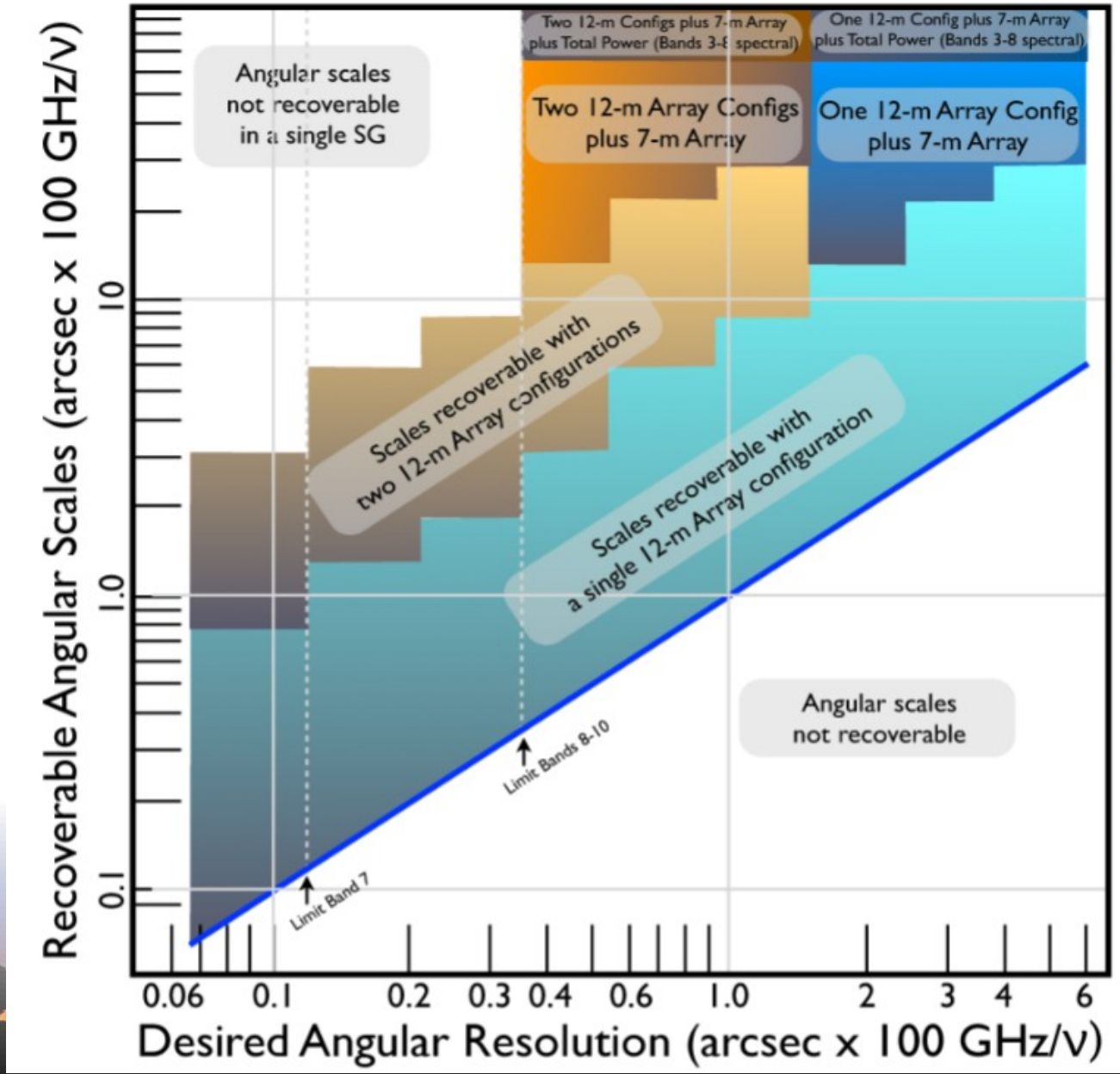


Angular scales in the OT

It is possible to combine
more configurations
but it might be time consuming

Simulations help in assessing
the requests.

Resolution can be reduced
at the imaging stage



Mosaics

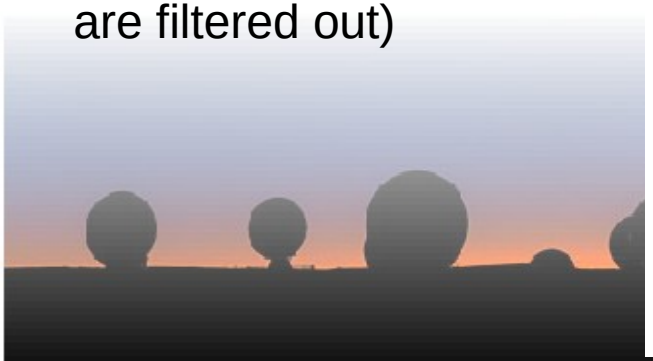
The Field of View **is the area on the sky over which an image is obtained depends on the antenna diameter D**

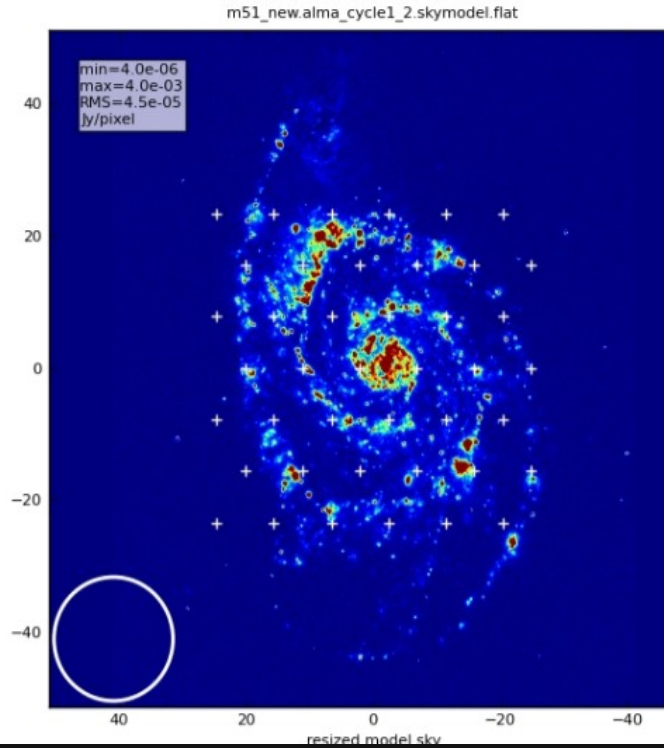
Sensitivity decreases with distance from the FOV center as a Gaussian profile
→ If the map region is larger than 1/3 of the FOV a mosaic is suggested

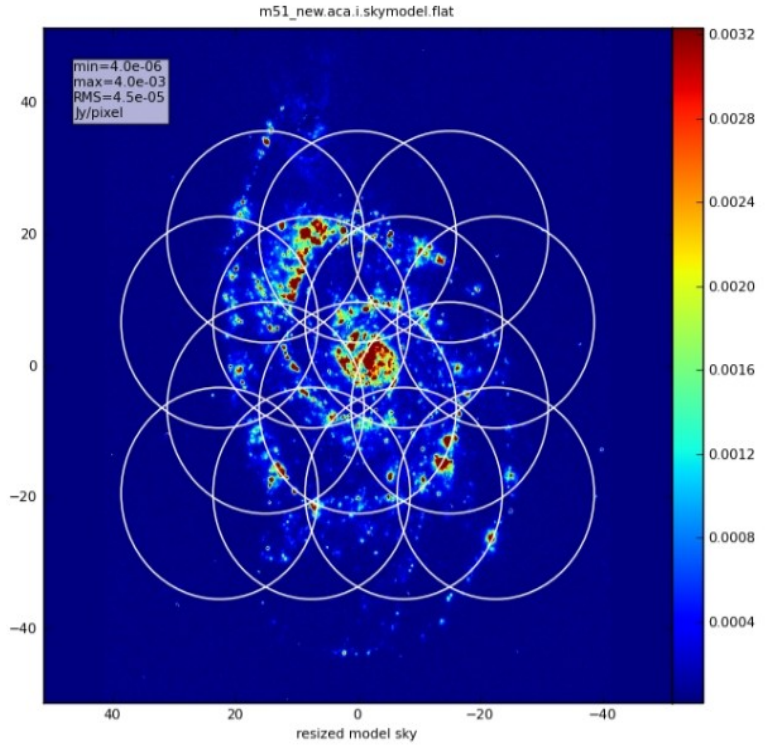
Mosaics are obtained by setting pointings with overlapping fields of view

By Nyquist sampling an homogeneous sensitivity is obtained over the mapped area
→ pointings should be separated by at most λ/2D (D=antenna diameter)

Mosaics map larger areas than single pointings but on the same angular scales (i.e. at first order scales larger than that corresponding to the minimum baseline are filtered out)



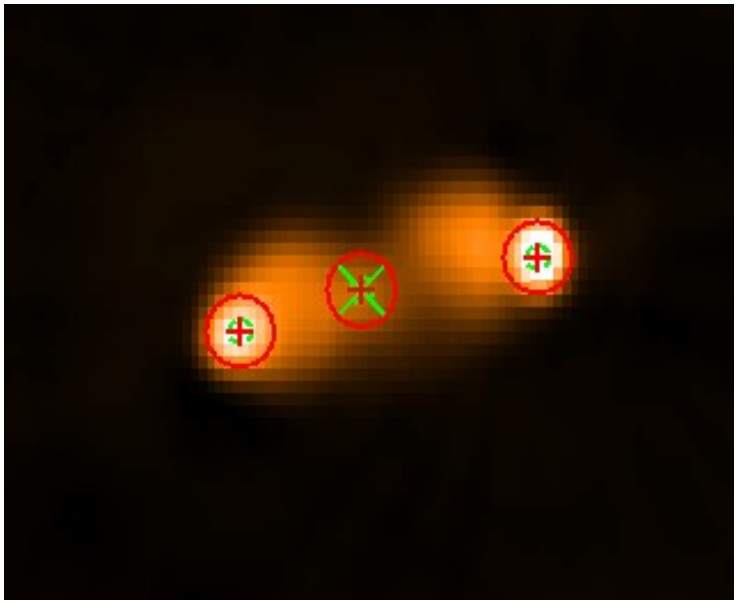


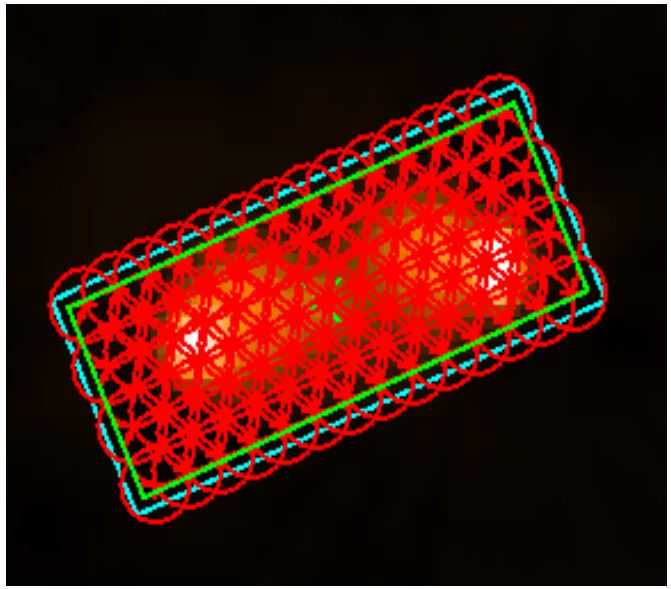


Mosaics vs Multiple Pointings

Mosaic allows homogeneous sensitivity over an extended area
(e.g. to map extended structures over a region)

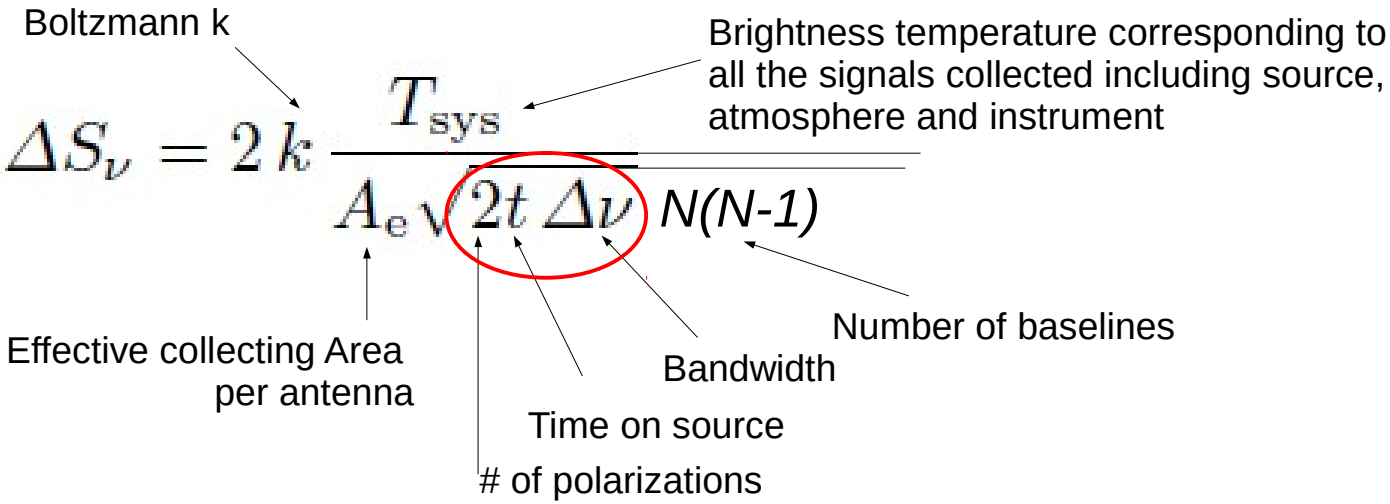
Multiple Pointings allows to get the highest sensitivity at the center of the poitings (e.g. for point sources spread over a region)





Sensitivity

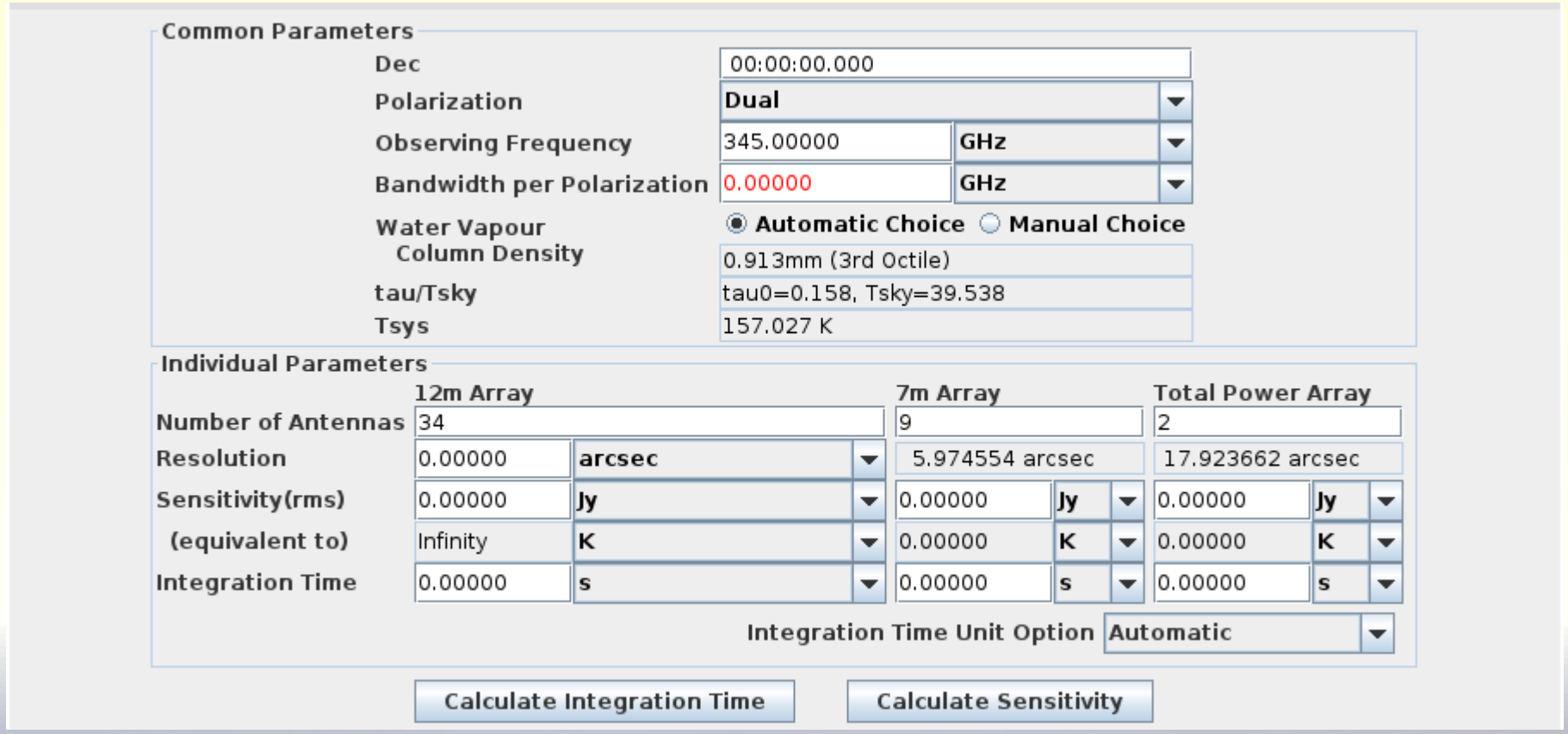
The rms noise in the signal for a radiometer is given by:



Sensitivity can be increased by increasing the bandwidth and/or the integration time

Sensitivity Calculator

https://almascience.eso.org/proposing/sensitivity-calculator

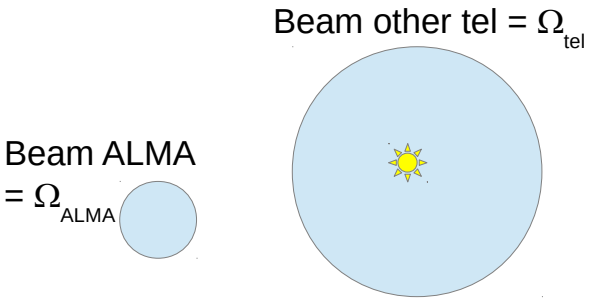


Source Peak Flux Density

In the OT you should indicate the Peak Flux densities and sensitivity
at the requested frequency and resolutions.
What to do if the literature data you have come from an observation with different resolutions?

1) The source is smaller than the ALMA beam

Flux density in Jy/beam is independent from the beam area

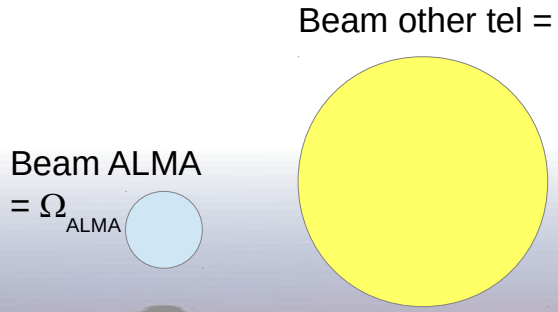


$$F_{ALMA}=F_{tel}$$

$$\left(\frac{T}{1\ \mathrm{K}}\right)=\left(\frac{S_\nu}{1\ \mathrm{Jy}}\right)\left[13.6\left(\frac{300\ \mathrm{GHz}}{\nu}\right)^2\left(\frac{1''}{\theta_{max}}\right)\left(\frac{1''}{\theta_{min}}\right)\right]$$

2) The source is larger than the ALMA beam

Flux density in Jy/beam depends on the beam area (i.e. on the beam FWHM θ)

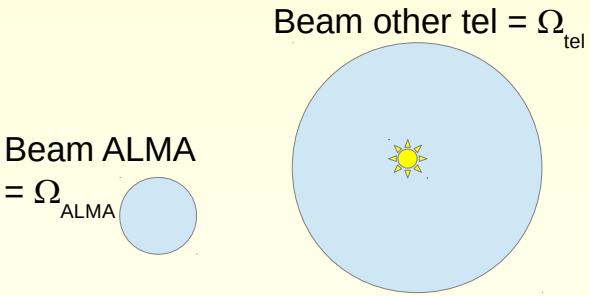


$$F_{ALMA}=F_{tel}(\Omega_{ALMA}/\Omega_{tel})=F_{tel}(\theta_{ALMA}/\theta_{tel})^2$$

Source Peak Flux Density in time

A source is observed with a single dish with θ_{tel}=10” and has T_{tel}= 1 K at 300 GHz
Which is the sensitivity required for ALMA observations at θ_{ALMA}=1” resolution ?

1) The source is smaller than the ALMA beam

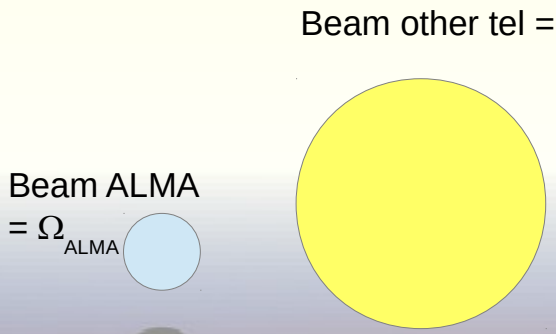


$$F_{tel} = 2\,k\,T_{tel}\Omega_{tel} / \lambda^2$$

$$F_{ALMA} = F_{tel} = 7.36 \text{ Jy/beam}$$

A factor 100 in flux
Corresponds to
A factor 10000 in time

2) The source is larger than the ALMA beam



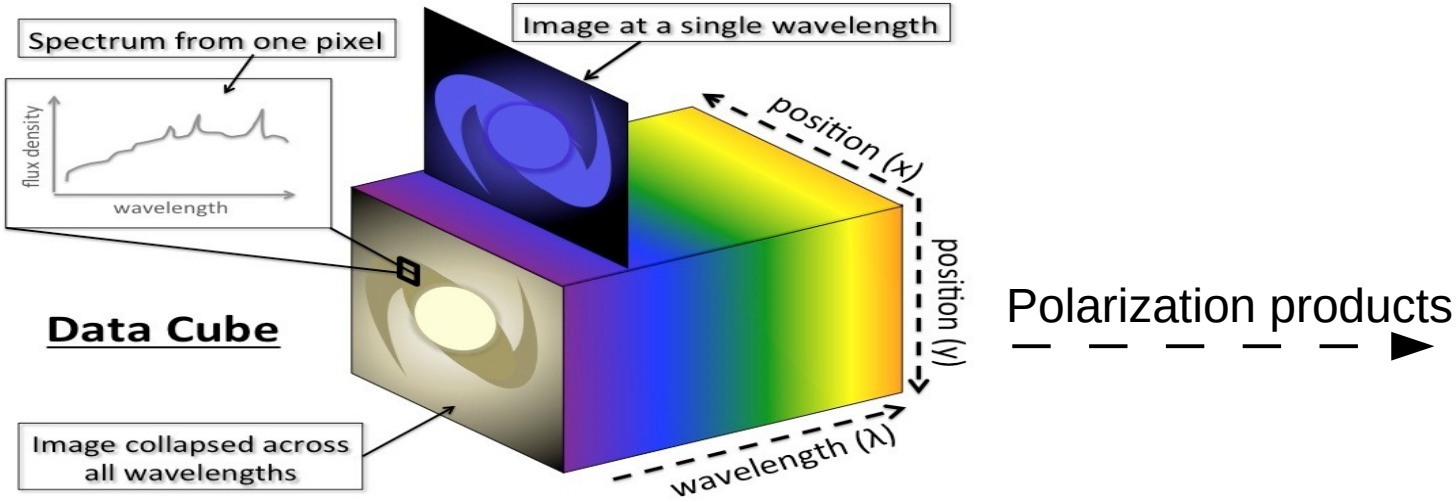
$$F_{tel} = 2\,k\,T_{tel}\Omega_{tel} / \lambda^2$$

$$F_{ALMA} = F_{tel}(\theta_{ALMA}/\theta_{tel})^2 = 0.0736 \text{ Jy/beam}$$

Choose carefully your resolution!!!

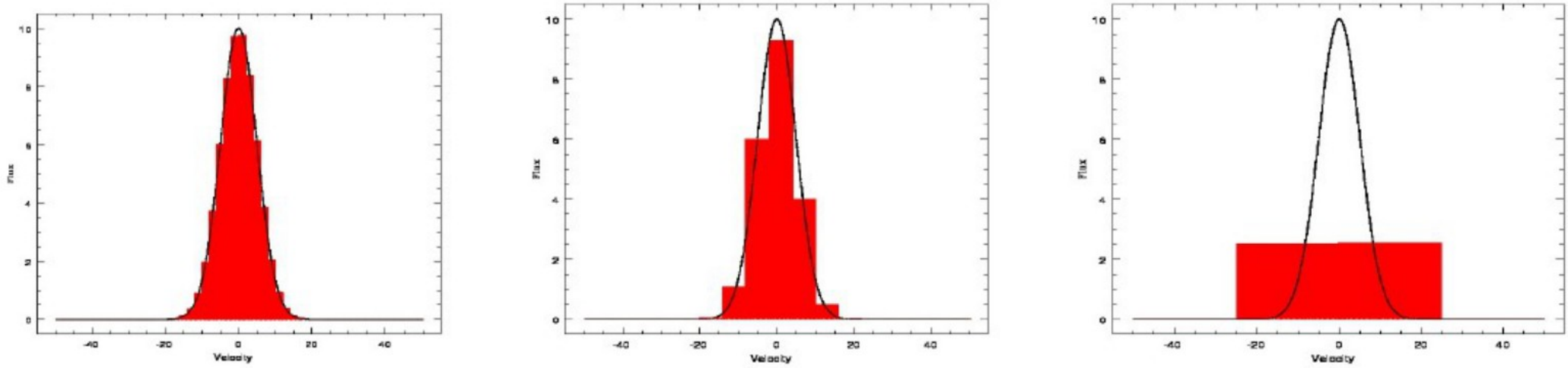
Spectral Resolution

The Spectral resolution **is the minimum separation in frequency whereby adjacent features can be distinguished.**
It depends on how the correlator is set.



Continuum bandwidth is as large as 7.5GHz/pol
The finest spectral detail you want to observe determines your resolution in the ranges
from 0.1-111 km/s at 84 GHz to 0.01 - 10 km/s at 950 GHz.

Spectral resolution: lines



- If channel width < FWHM the peak flux is independent of channel width
- If the channel width is too large you lose in line details and eventually in sensitivity

- Choose at least 3 resolution elements per FWHM
- ALMA OT resolutions are always Hanning smoothed
- Smoothing at data reduction stage is possible (e.g. to increase sensitivity for broad lines)
- Channel averaging smooths data at acquisition stage
(i.e. finest resolution cannot be recovered later) but it is sometimes needed to reduce data rate.

- Remember that sensitivity depends on spectral resolution as rms(Jy) $\propto$ $1/\Delta\upsilon^{1/2}$
- $\Delta\upsilon$ [Hz] $=\upsilon$ [Hz] Δv [km/s] / c [km/s]

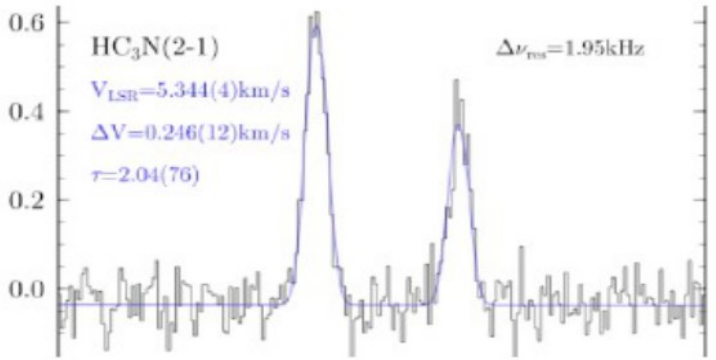
Sensitivity: spectral line

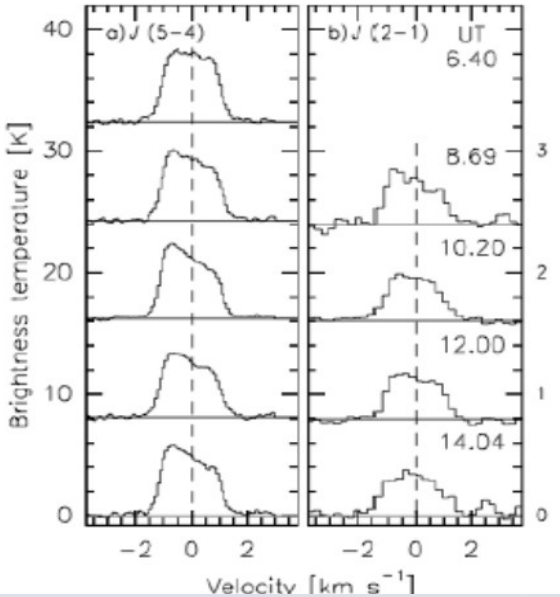
- Gaussian profile
  - SN on the peak

$$rms(Jy) = \frac{Area(Jy \cdot kms^{-1})}{FWHM(kms^{-1}) \cdot SN}$$

- Undefined profile
  - SN on the area

$$rms(Jy) = \frac{Area(Jy \cdot kms^{-1})}{N_{chan}^{1/2} \cdot \Delta v(kms^{-1}) \cdot SN}$$





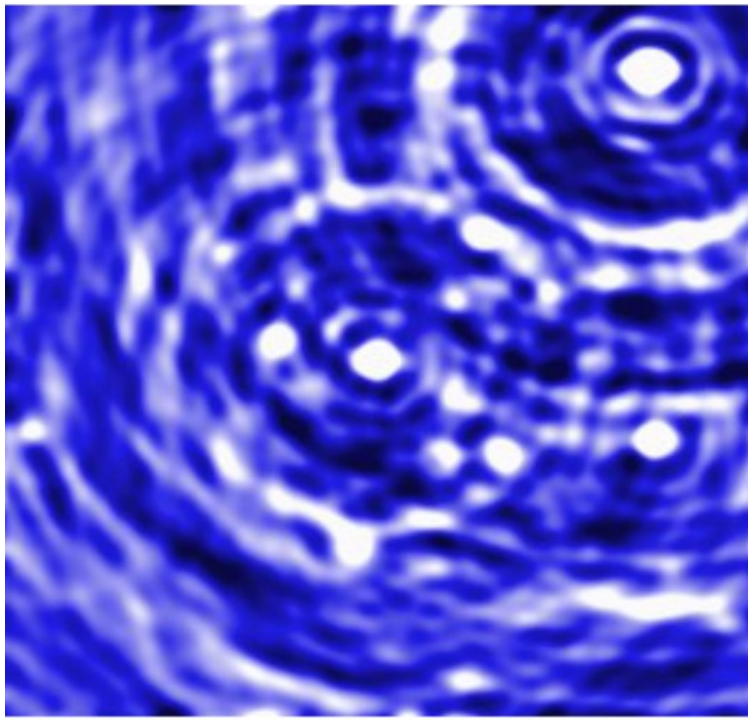
Imaging Dynamic Range

Bright sources in the field of view introduce strong sidelobes which affect the rms in the clean image

IDR= Max continuum flux / Requested RMS

ALMA expectations are:

- IDR~ 100 for Bands < 9
- IDR~ 50 for Bands 9 and 10
- Higher IDR must be justified!



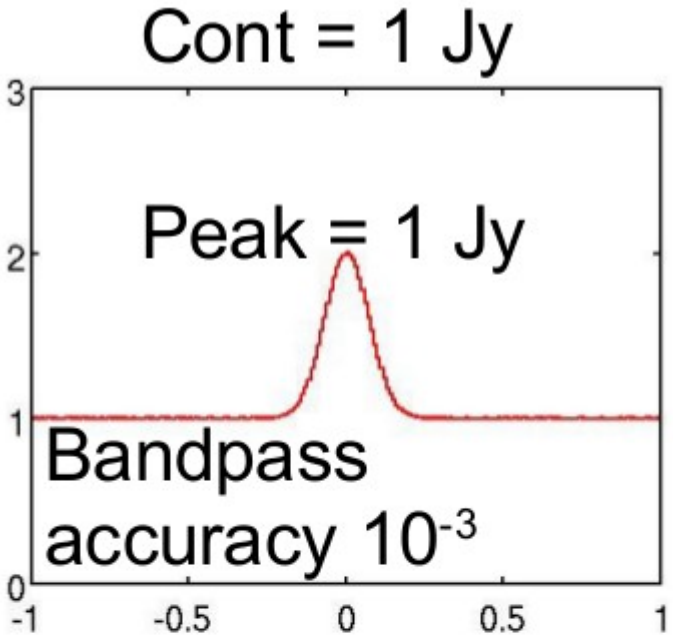
Spectral Dynamic Range

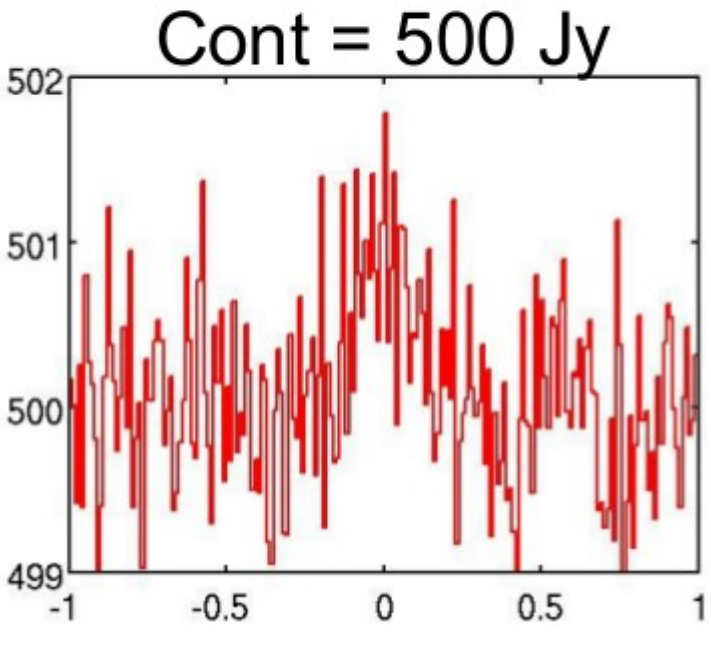
Uncertainties in bandpass calibration limit the capability of detecting faint spectral features over a strong continuum

SDR= Strongest detectable feature / channel rms

ALMA guarantees:

- SDR < 1000 for Bands < 9
- SDR < 500 for Bands 9 and 10
- Higher SDR must be justified!





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  - Sensitivity
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  - Spectral resolution
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Check the time and your requests

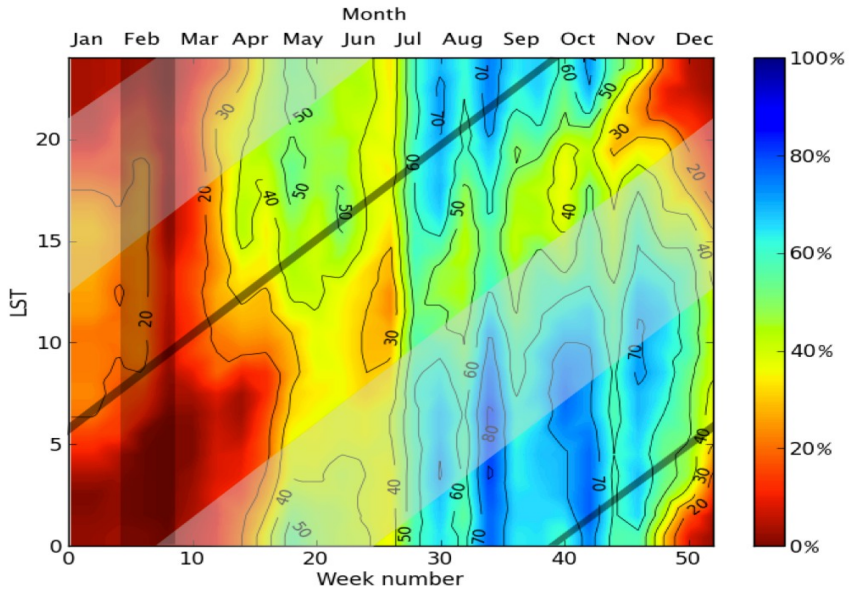
The angular resolution and LAS needed will determine the antenna configuration or configurations

The total time of the project increases depending on the configurations requested

→ Check if you really need more than one configuration

The configuration calendar define the period of the year when your target will be observed.

→ If you are planning a high frequency observation check carefully that the period needed for its observation does not coincide with the Altiplanic winter or daytime.



Check the time and your requests

The achievement of the requested sensitivity will be checked at the requested bandwidth (that can be different from the observing spectral resolution but better if it is lower) within a beam equal to the requested resolution

→ Choose carefully your reference target (typically the first of the SG)
reference frequency
requested sensitivity, bandwidth for sensitivity and resolution
sort the SGs according to their priority if needed

Don't average if it is not really needed to reduce the data rate

→ You can always smooth the angular or spectral resolutions at imaging stage

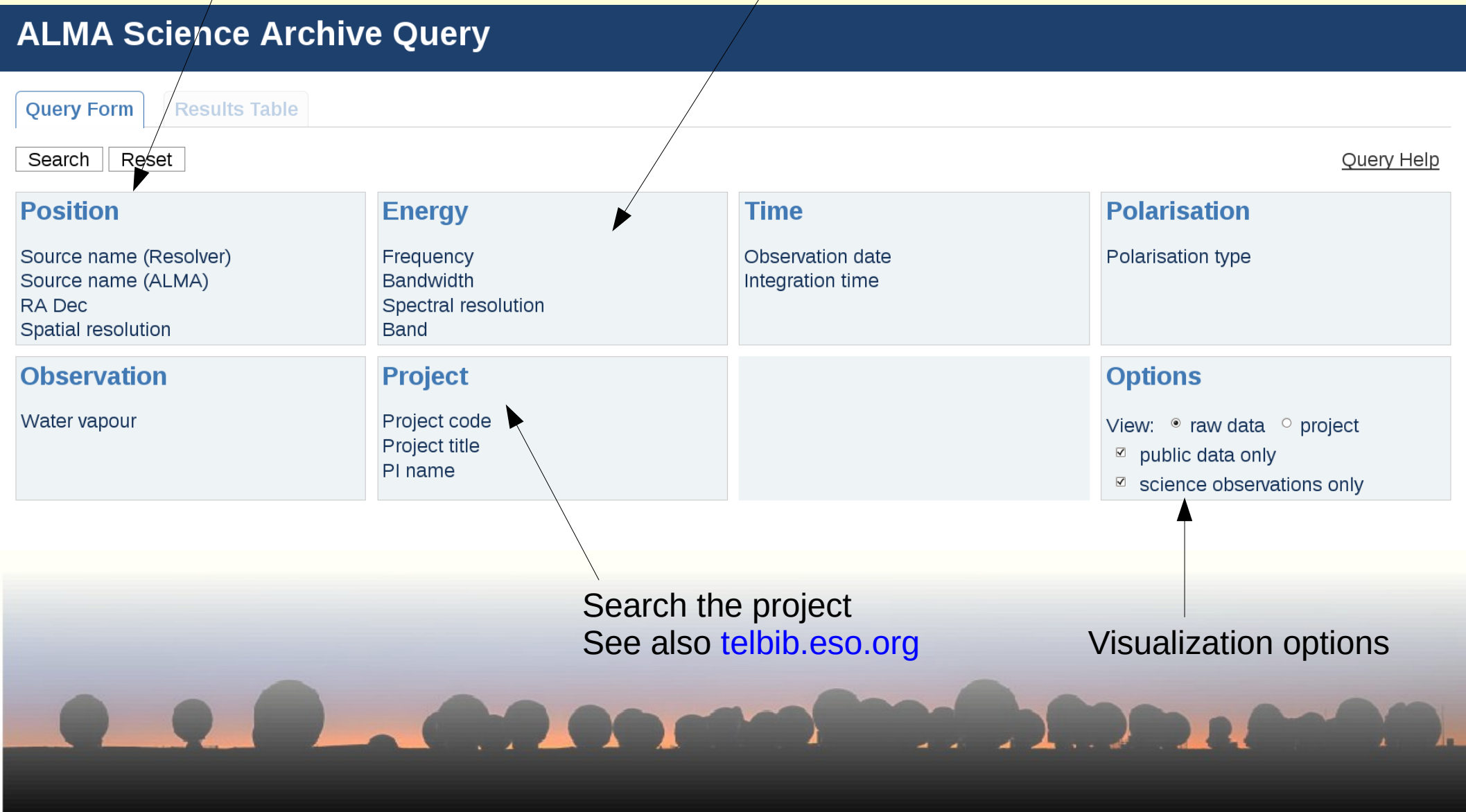
Simulations are not necessary, but take a few minutes to check the ALMA Science Archive to see if your target has ever been observed with ALMA

The ALMA Archive

https://almascience.eso.org/aq/

Search per name or position or within a radius

Search the spectral setup



Search the project
See also telbib.eso.org

Visualization options