

# Introduction to the basic concepts and terminology of radio interferometry



EUROPEAN ARC  
ALMA Regional Centre || Germany



Universität zu  
*Köln*

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German ARC node – April 2018



# Outline

## Part 1

- Introduction to aperture synthesis
- Interferometers: spatial filters

## Part 2

- An overview to the correlator and spectral receivers
- Interferometers: spectral setup





# Part 1: aperture synthesis, spatial filters

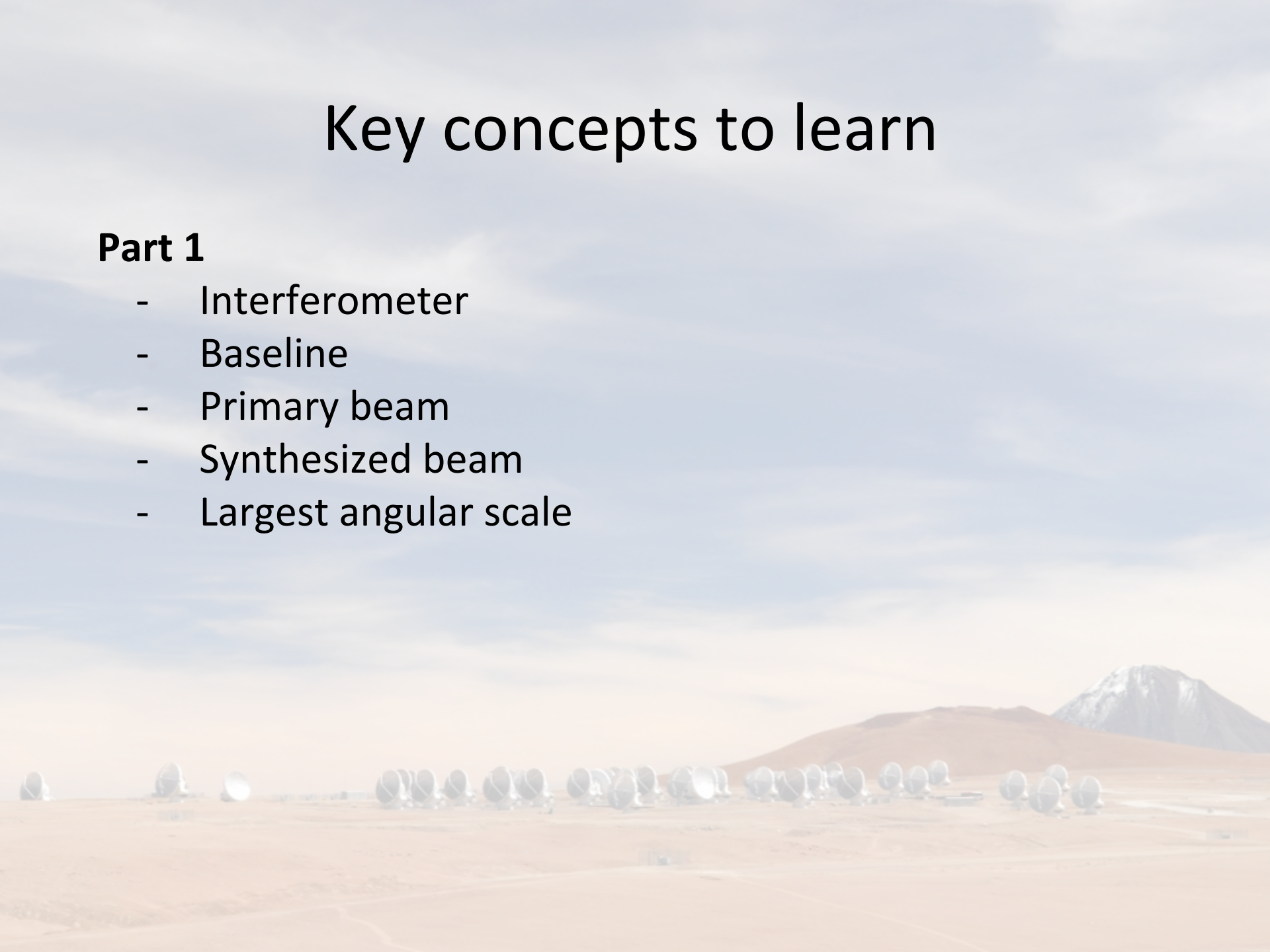


German ARC node

# Key concepts to learn

## Part 1

- Interferometer
- Baseline
- Primary beam
- Synthesized beam
- Largest angular scale





# Telescopes ... vs Radiotelescopes



Il "cannocchiale" di Galileo



Galileo Galilei

# Telescopes ... vs Radiotelesc

Where should I put the eye?  
the eye?



Il **NUOVO** "cannocchiale" di **Campione (Sàrdia)** Galileo

Galileo Galilei



# Atacama Large Millimeter/submillimeter Array



# Where is ALMA?

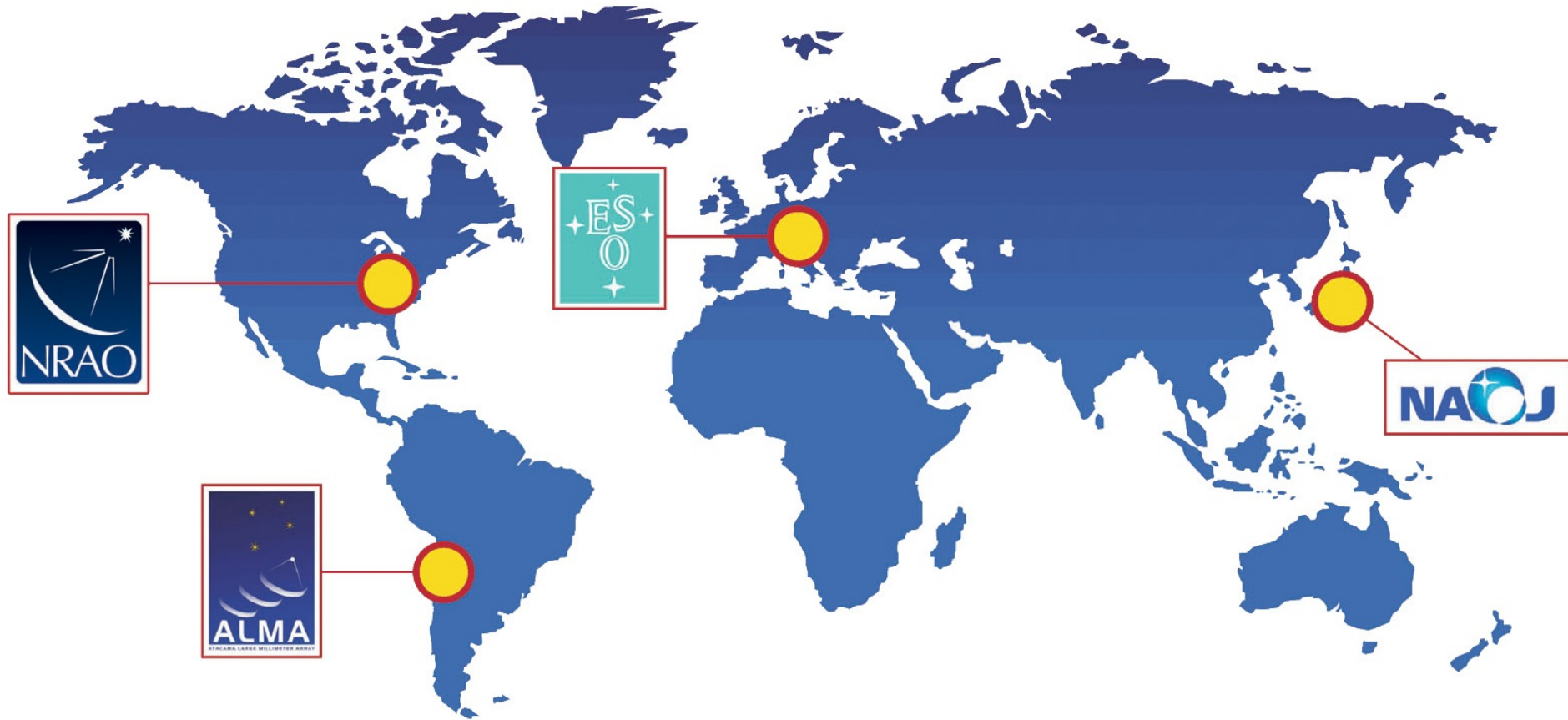
# Atacama desert (Chile)

- ... on the Chajnantor Plateau
- at 5000 m height
- ... control center
- at 2900 m height





# What is ALMA?



International collaboration:

3 ARC (ALMA Regional Centers) + JAO (Joint ALMA Observatory)

# What is ALMA?

ALMA is ...

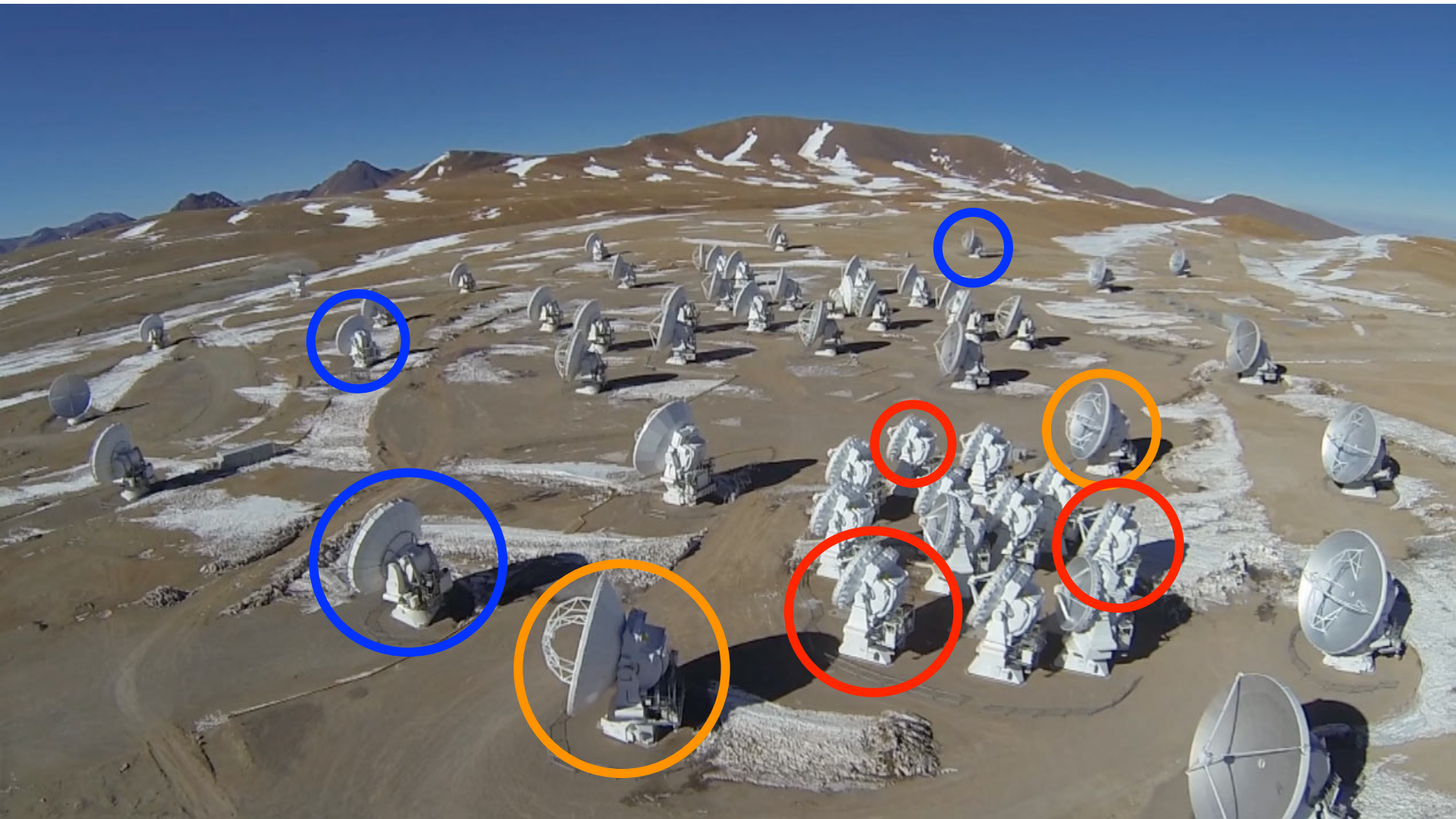




# What is ALMA?

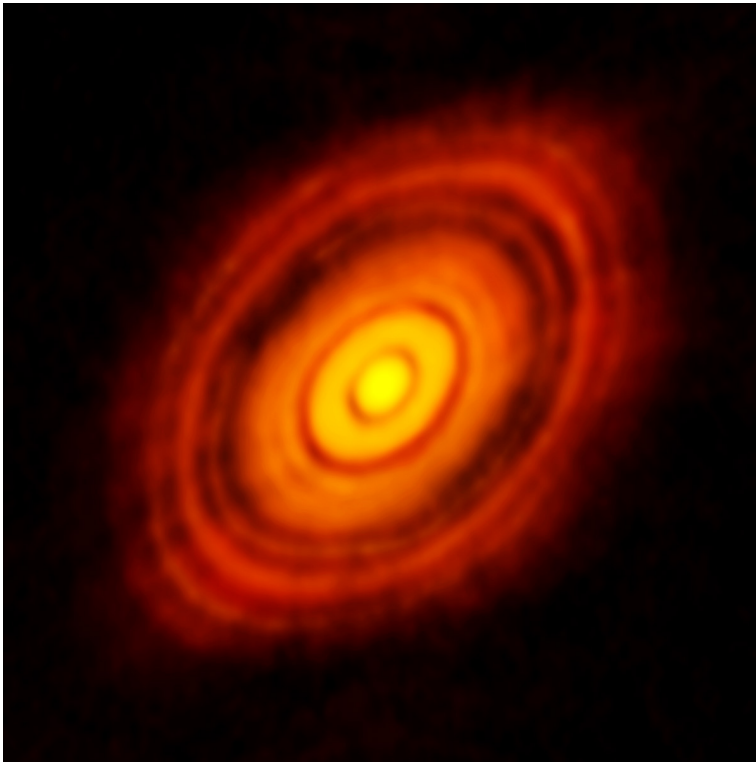
ALMA is ...

50x 12m antennas (main)  
12x 7m antennas (ACA)  
4x 12m antennas (TP)



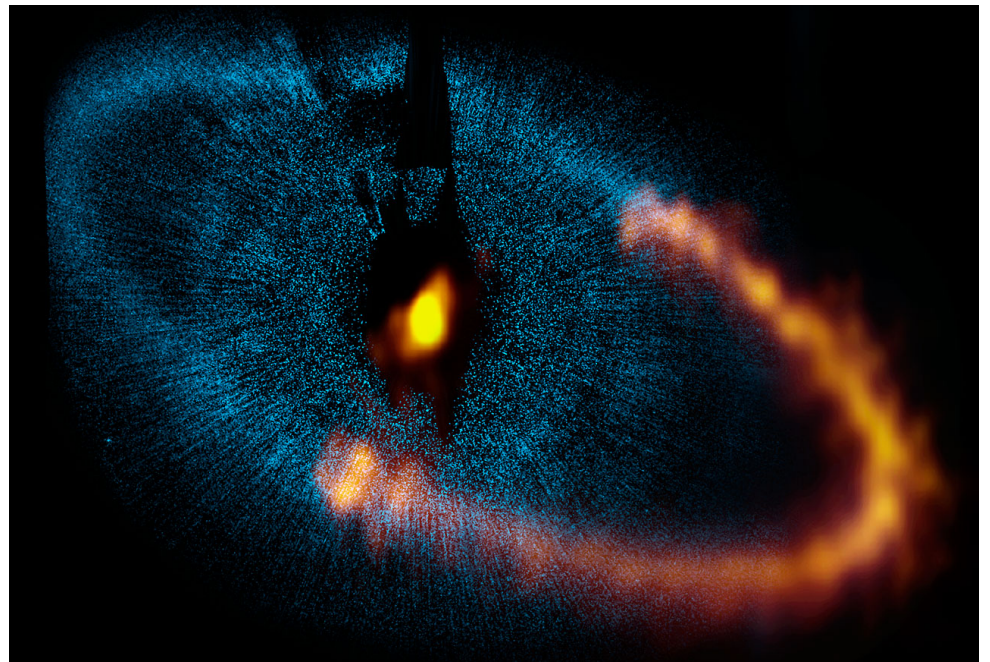
# What can ALMA do?

HL Tau



protoplanetary disks

Formalhaut

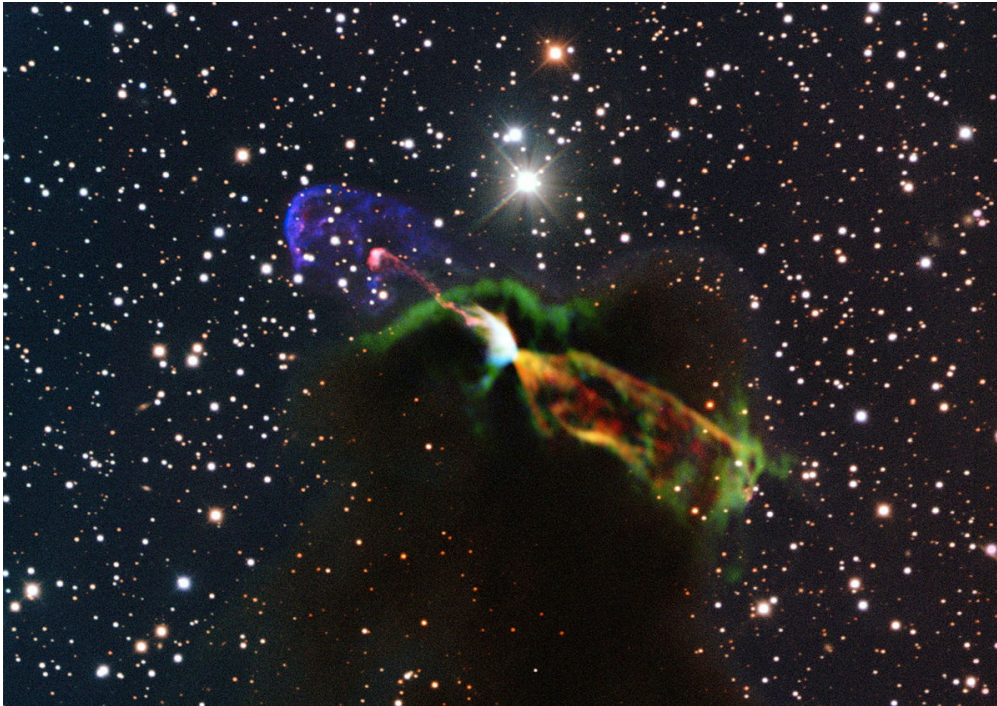


debris disks



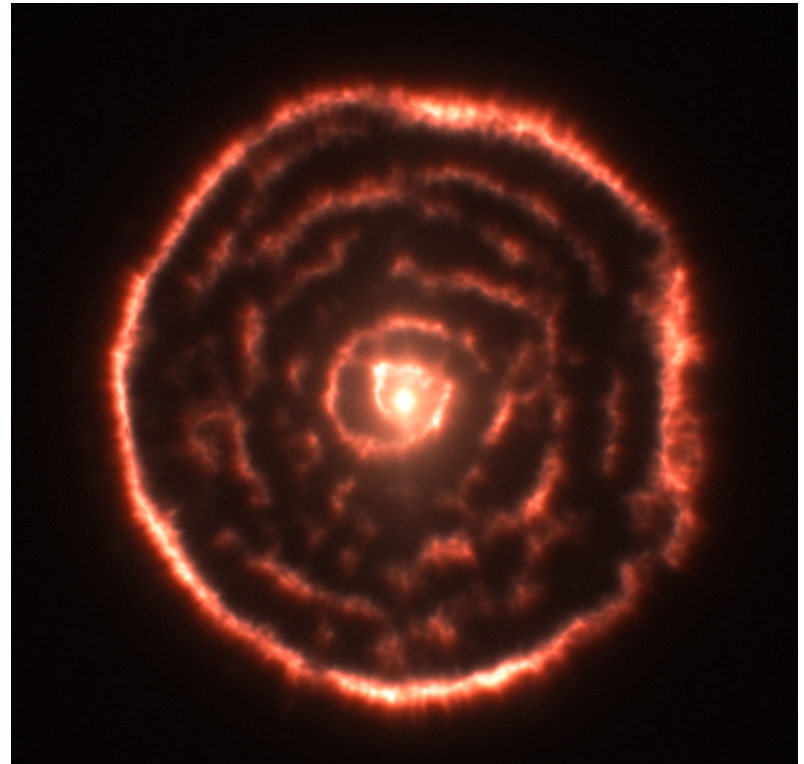
# What can ALMA do?

Herbig-Haro 46/47



molecular outflows and jets

R Sculptoris



red giants and old stars



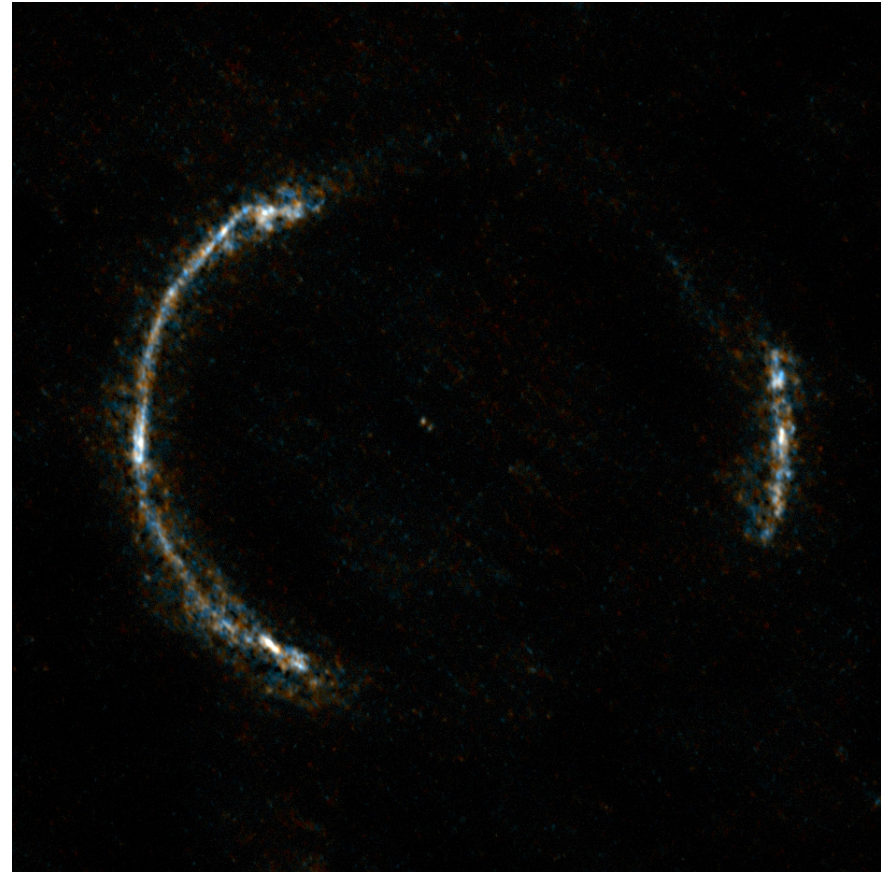
# What can ALMA do?

Antennae galaxies



galaxy mergers

SPD.81



lensed galaxies

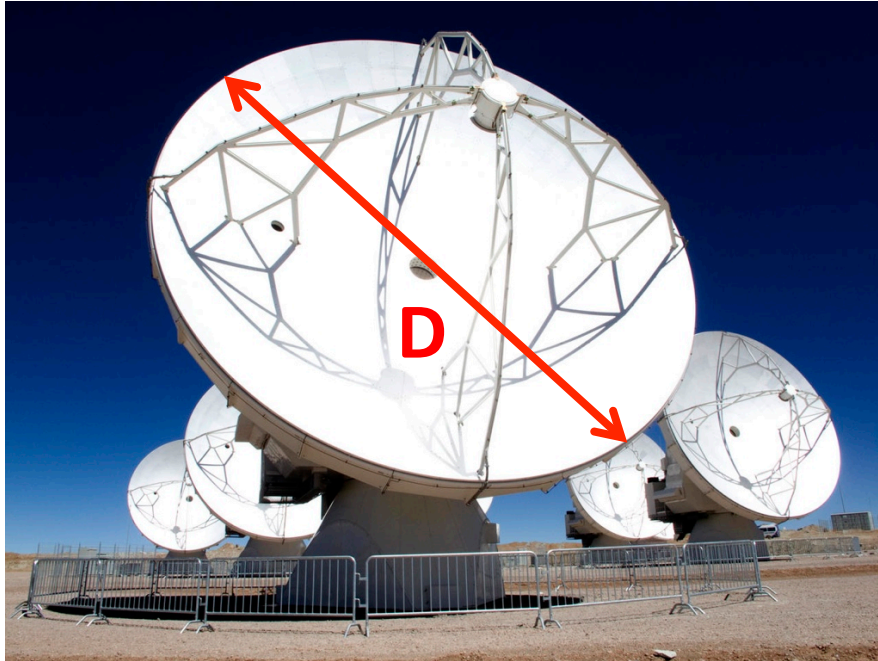


Why does ALMA need so many antennas?

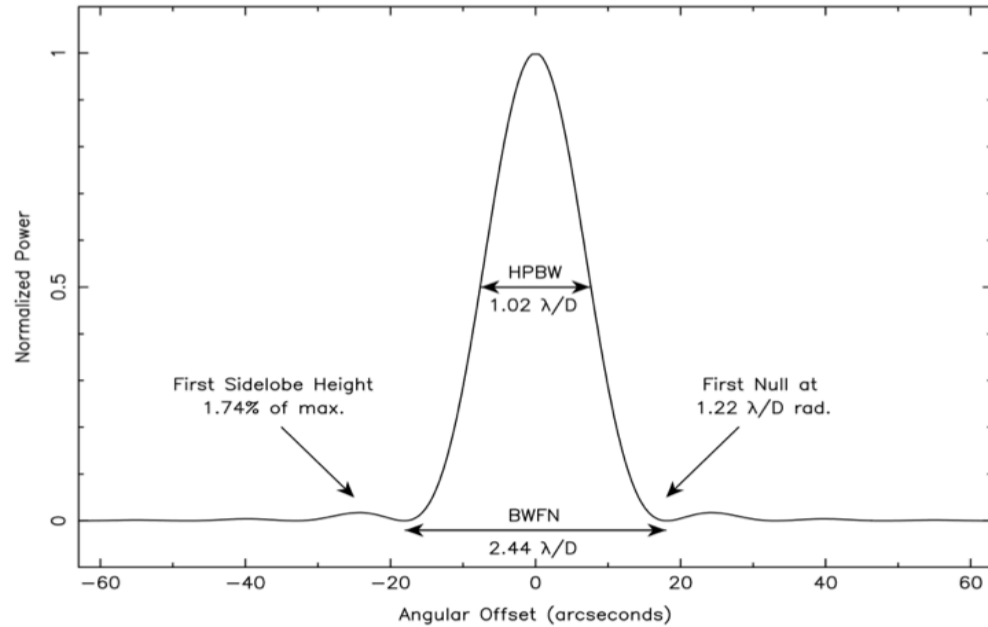


... consider one single antenna (or single-dish)

Single-dish with diameter  $D$



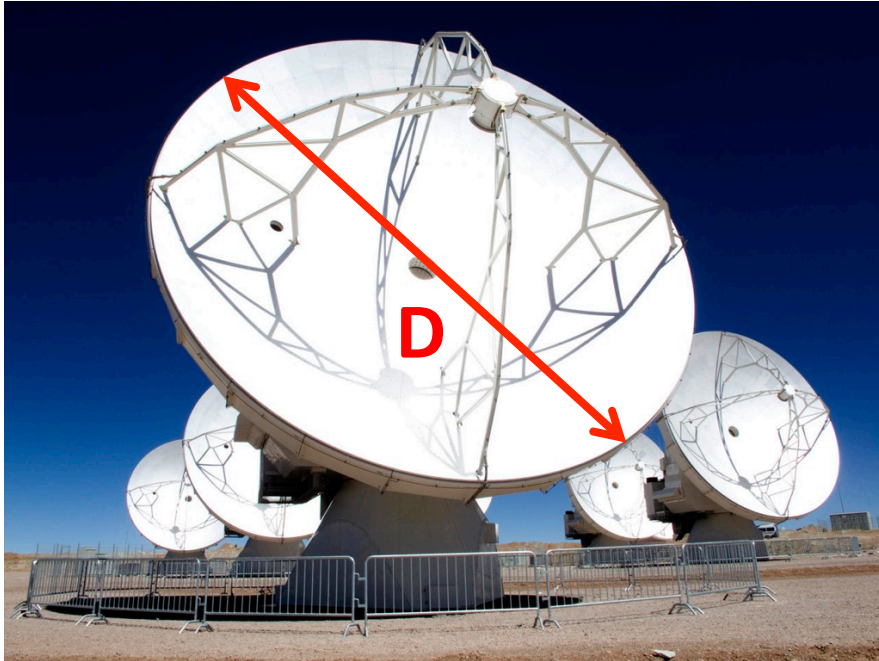
(1D) antenna power response



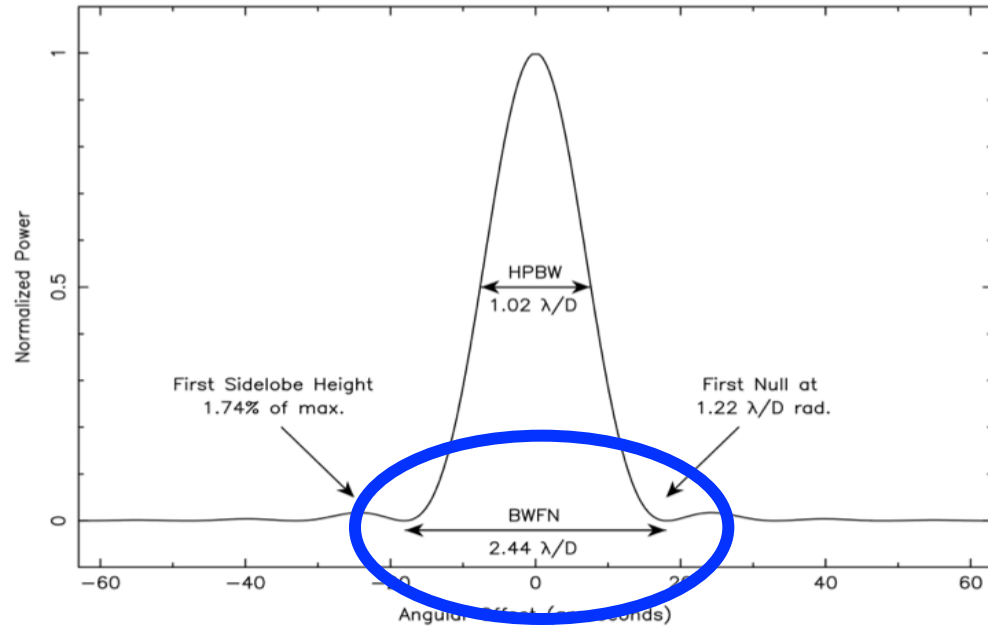


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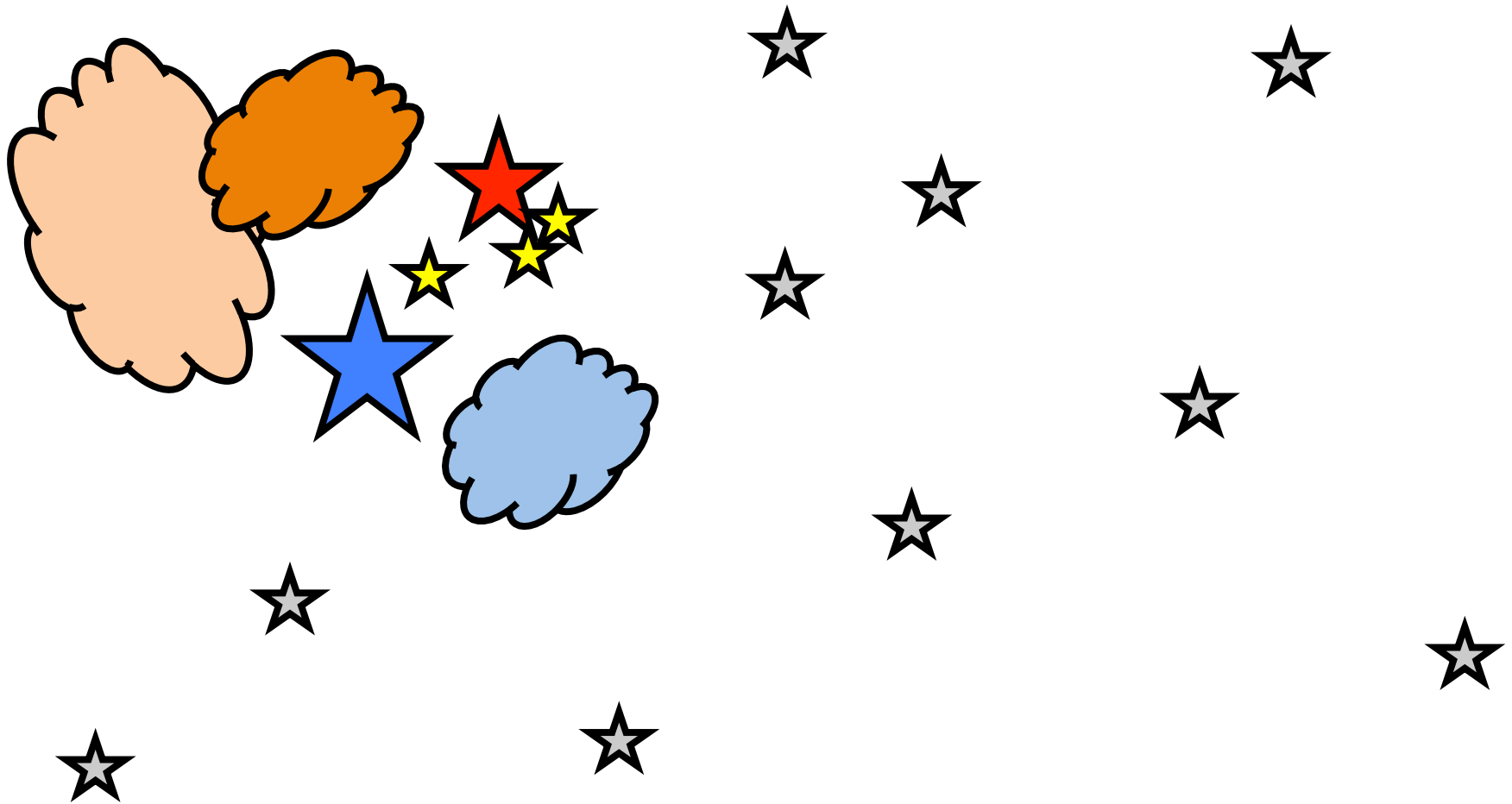
(1D) antenna power response



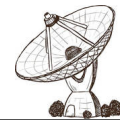
$$PB = 1.22 \frac{\lambda}{D}$$

PRIMARY BEAM

# Single-dish telescope

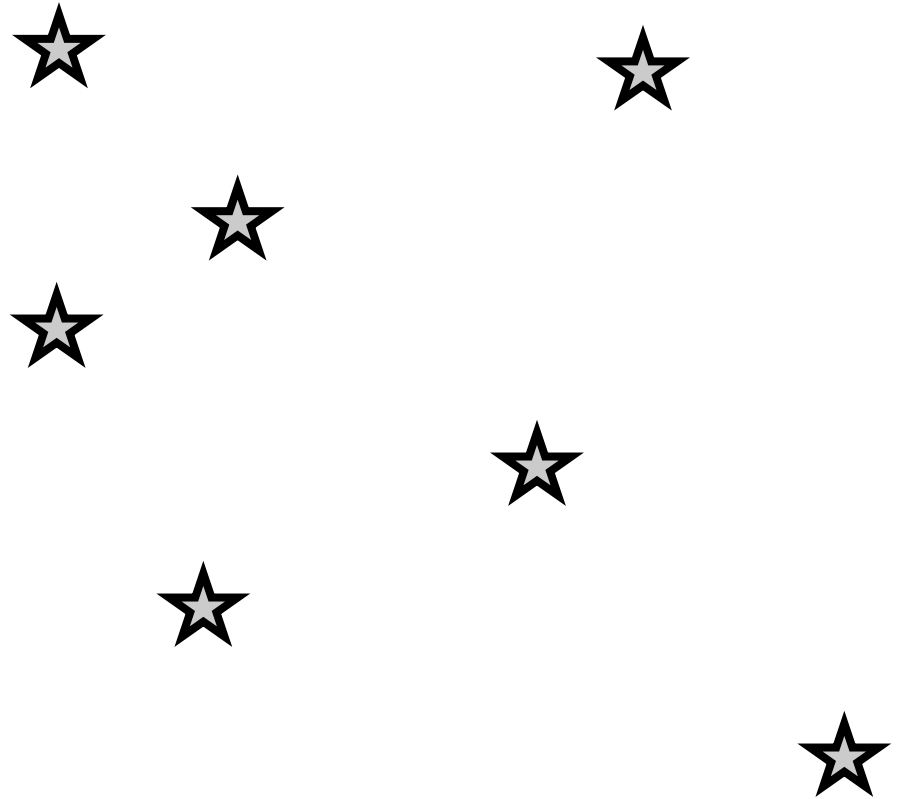
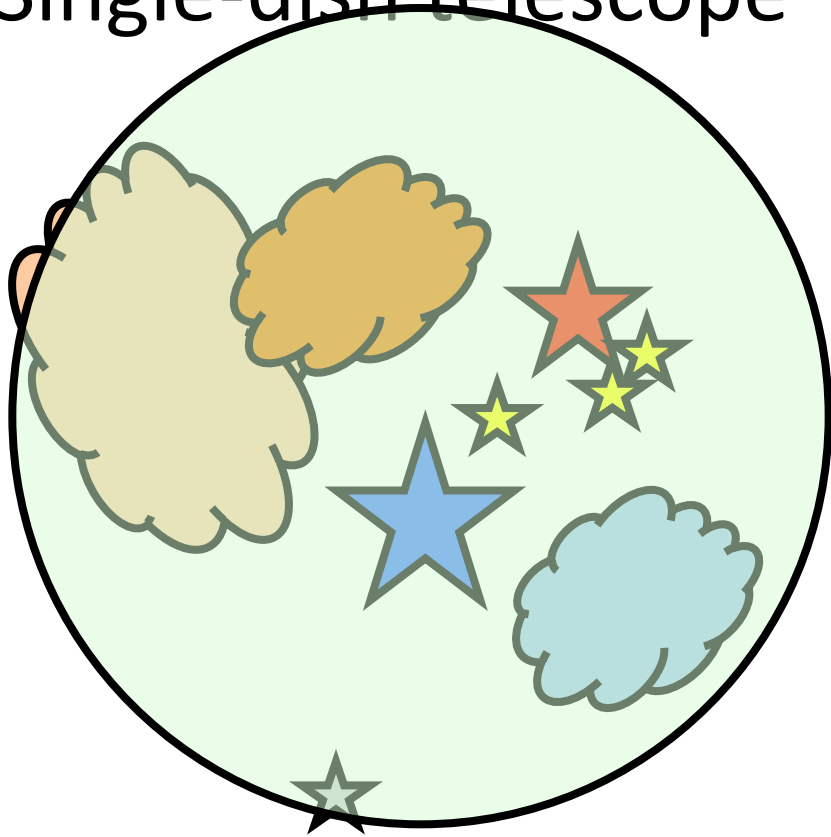


$$PB = 1.22 \frac{\lambda}{D}$$





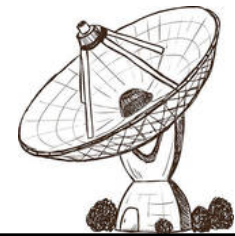
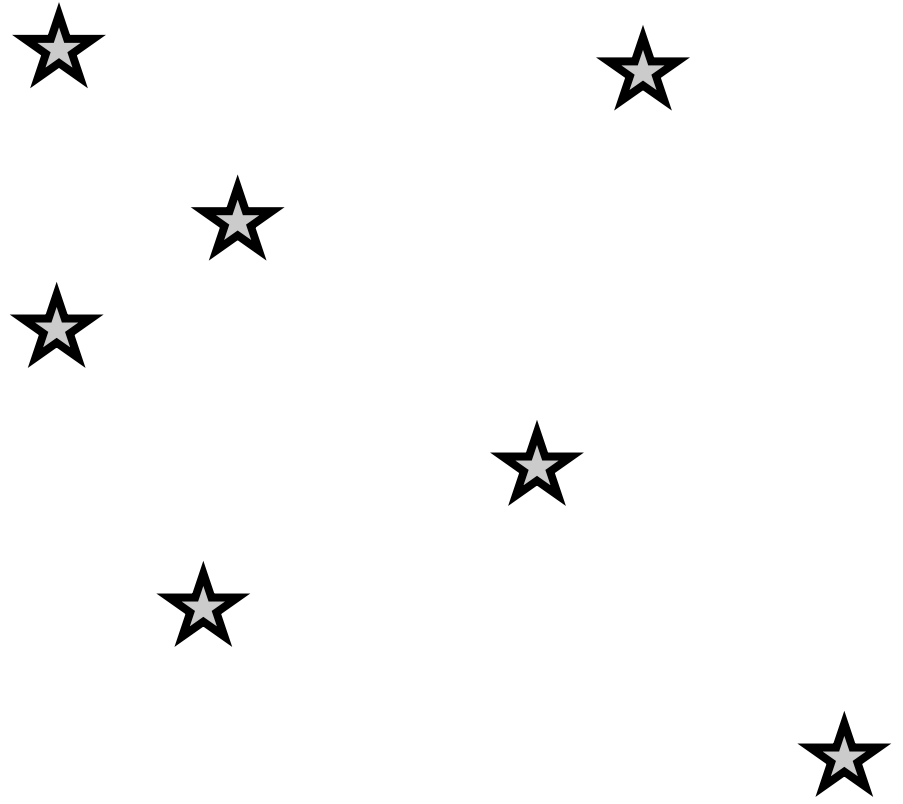
# Single-dish telescope



$$PB = 1.22 \frac{\lambda}{D}$$

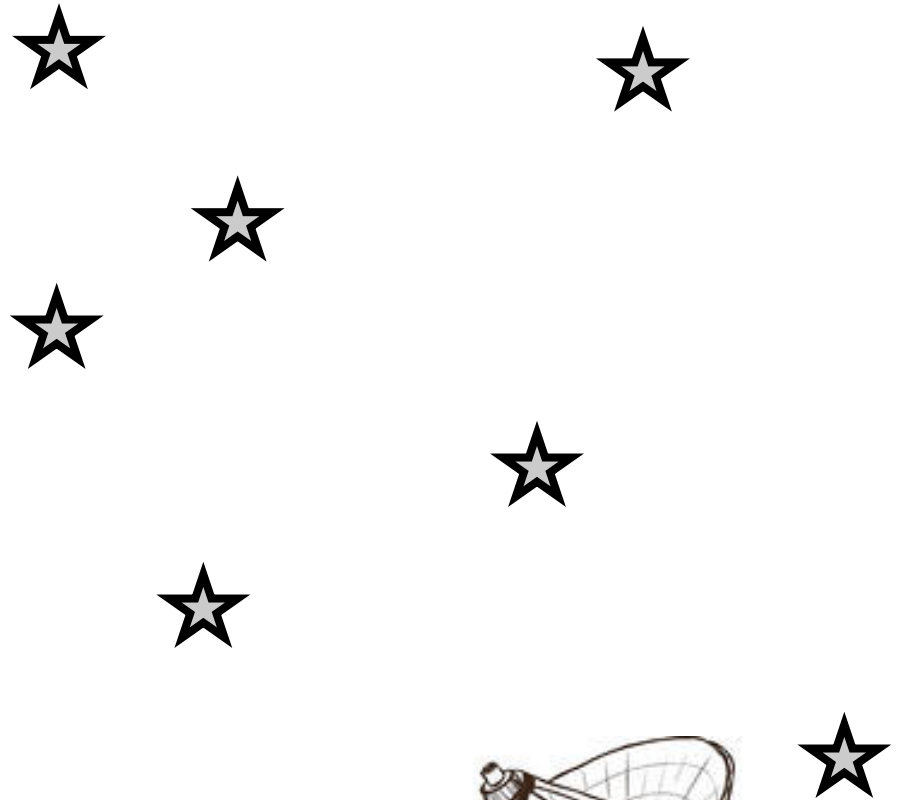


# Single-dish telescope



$$PB = 1.22 \frac{\lambda}{D}$$

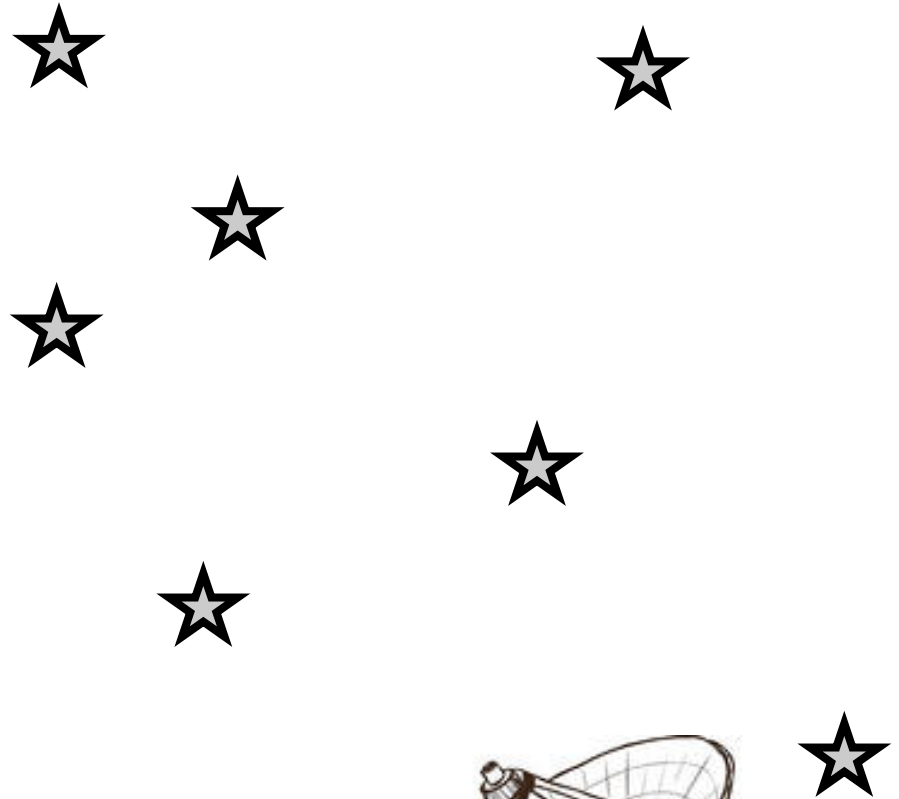
# Single-dish telescope



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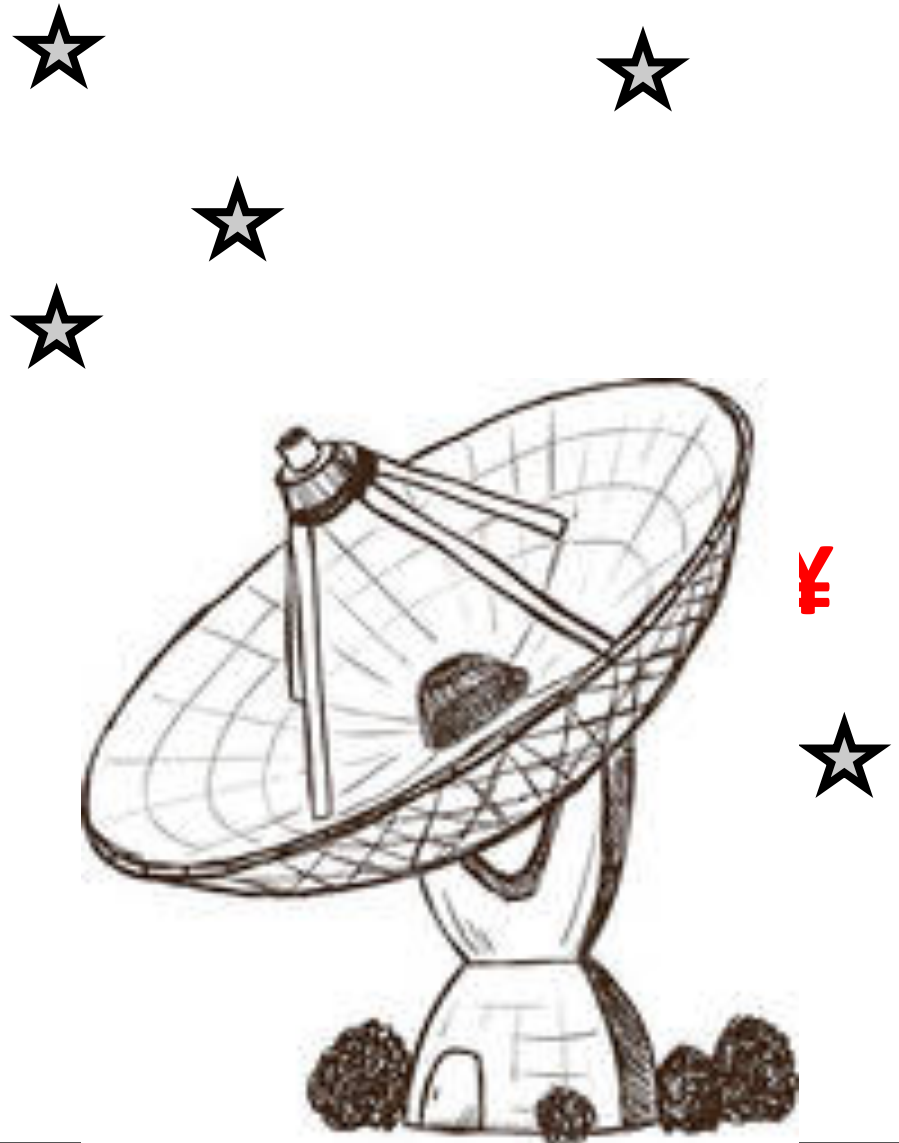


# Single-dish telescope



$$PB = 1.22 \frac{\lambda}{D}$$

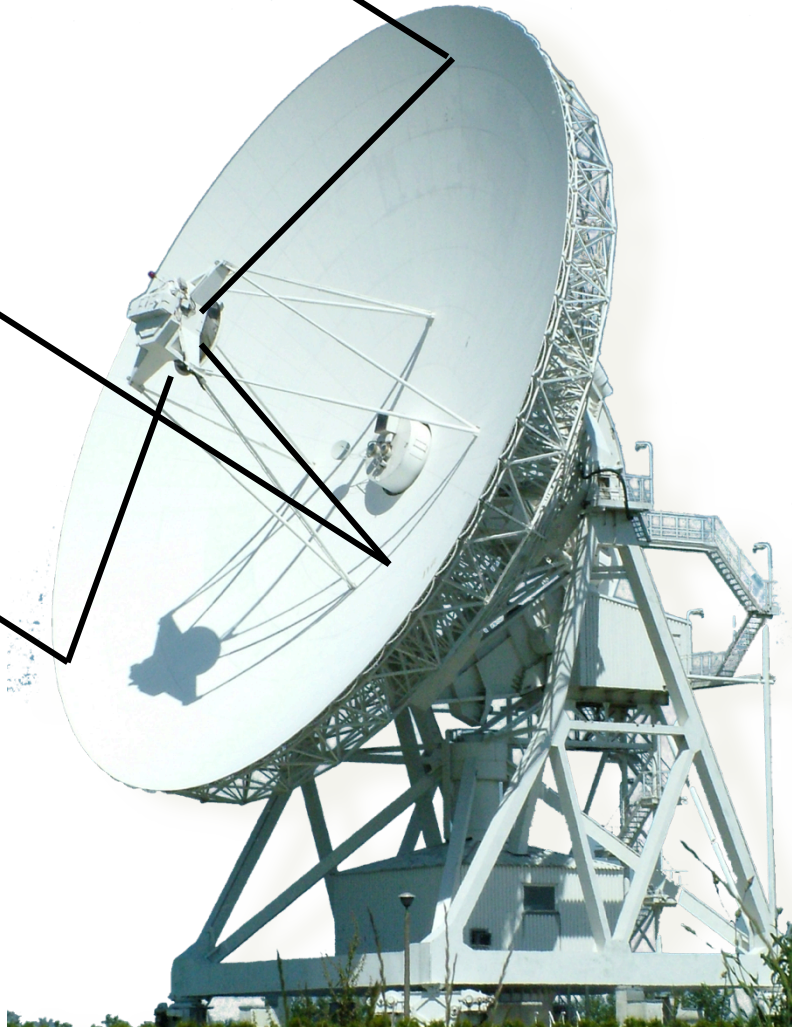
# Single-dish telescope



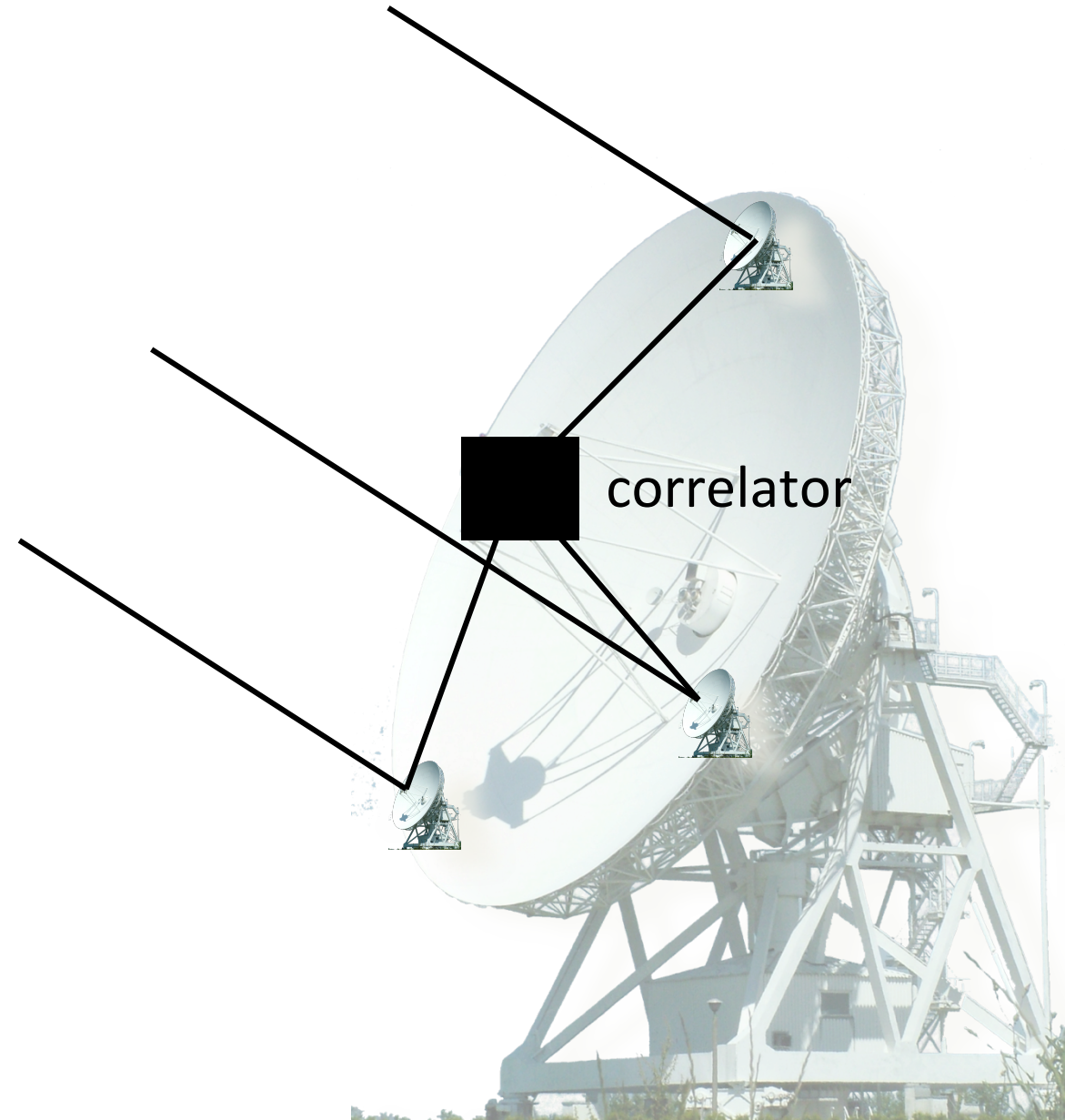
$$PB = 1.22 \frac{\lambda}{D}$$



# Interferometer – multiple dishes

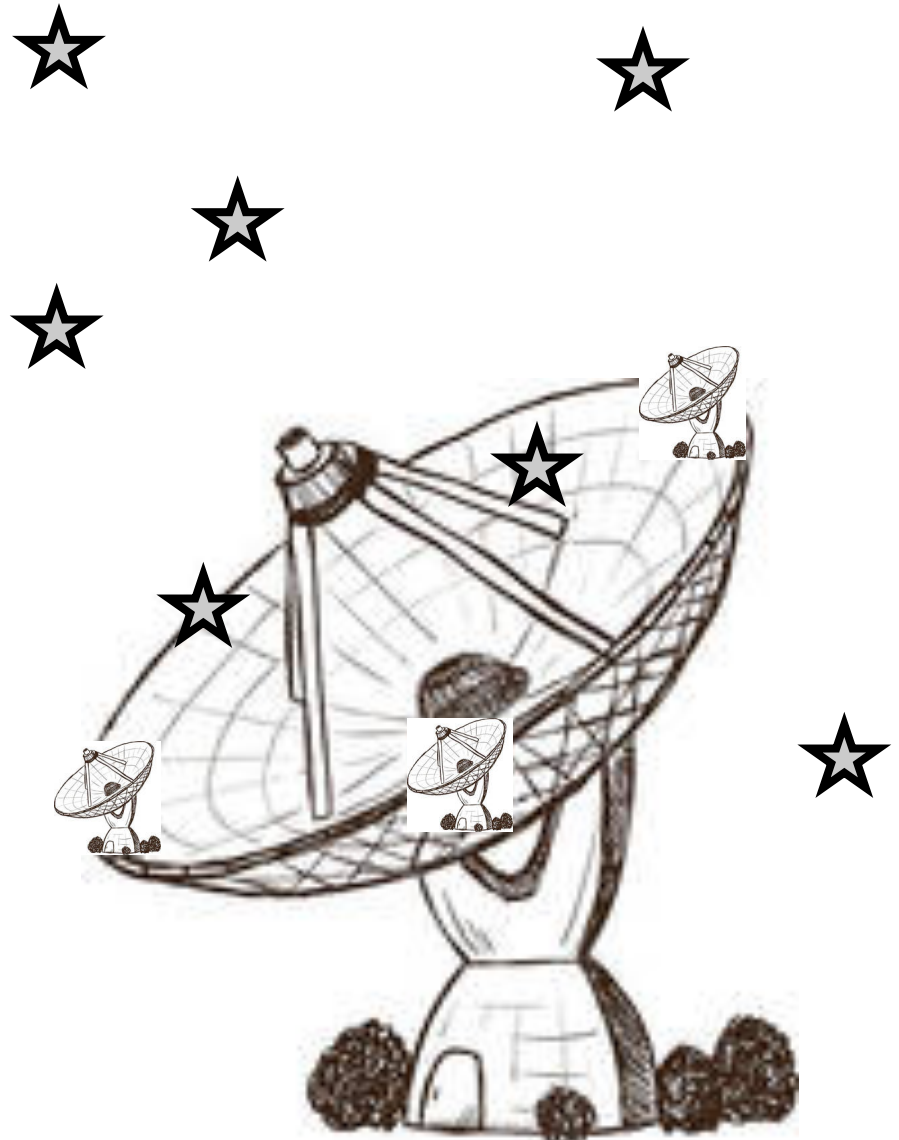


# Interferometer – multiple dishes





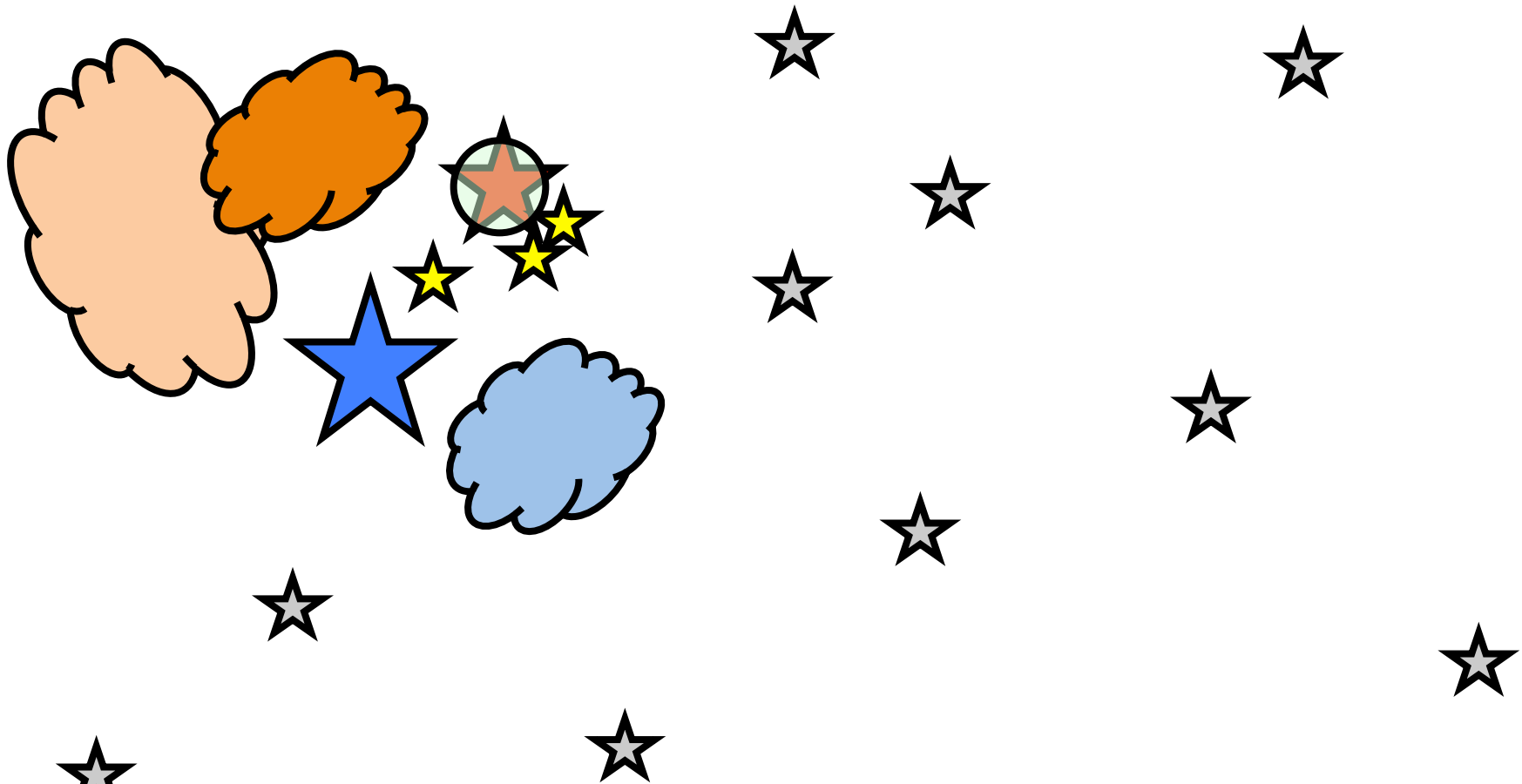
# Interferometer – multiple dishes



$$B_{mn} = \pm \lambda \frac{2\pi}{DB}$$

Baseline

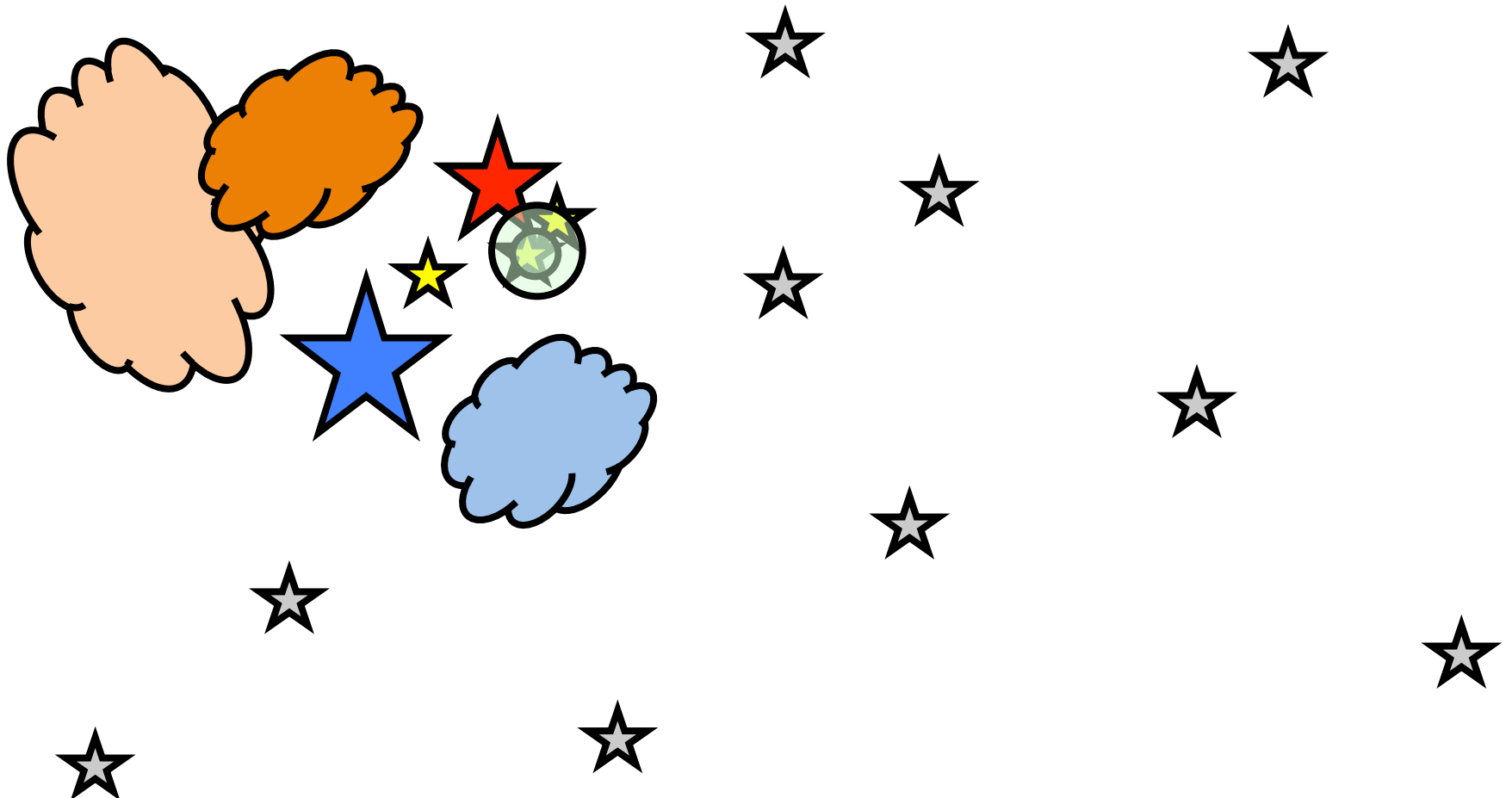
# Interferometer – multiple dishes



$$Beam = 1.22 \frac{\lambda}{B}$$

Baseline

# Interferometer – multiple dishes



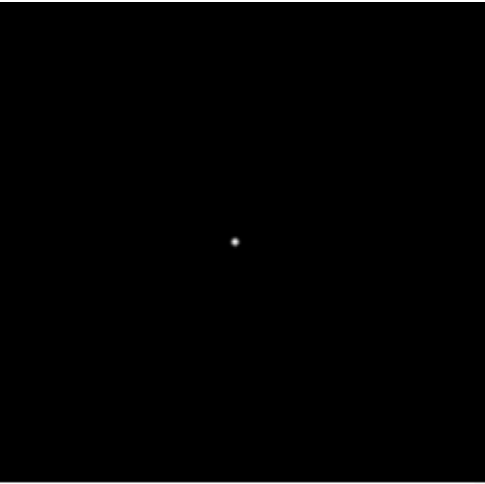
$$Beam = 1.22 \frac{\lambda}{B}$$

Baseline



# Interferometer – multiple dishes

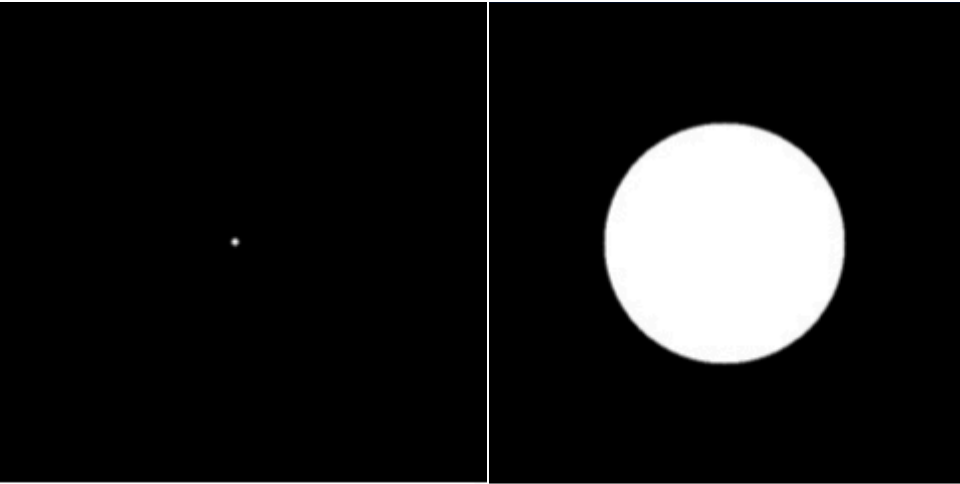
Small Single-Dish



**ABCD**  
**12345678**  
**9012345678**  
**9012345678**  
**9012345678**

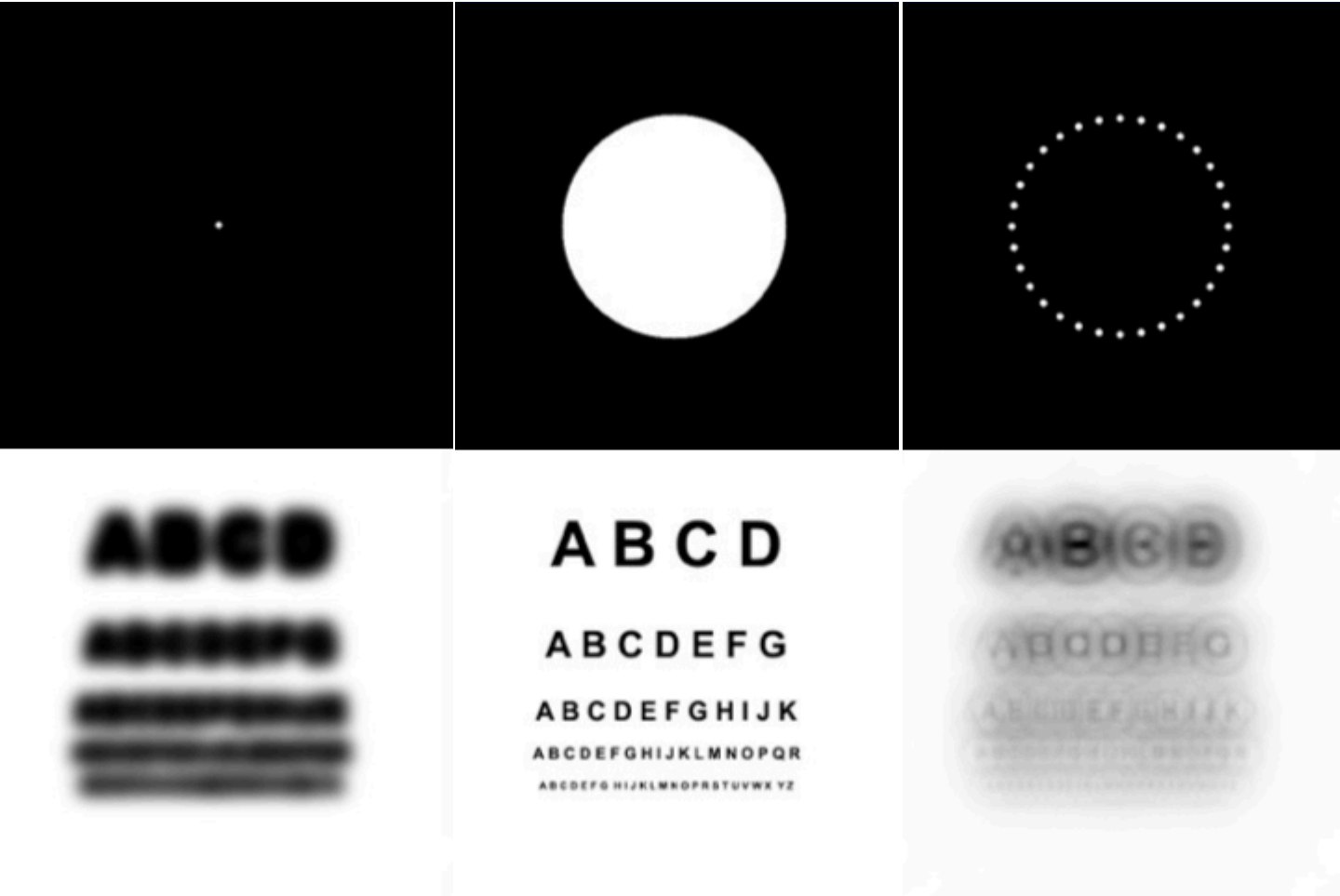
# Interferometer – multiple dishes

## Large Single-Dish



# Interferometer – multiple dishes

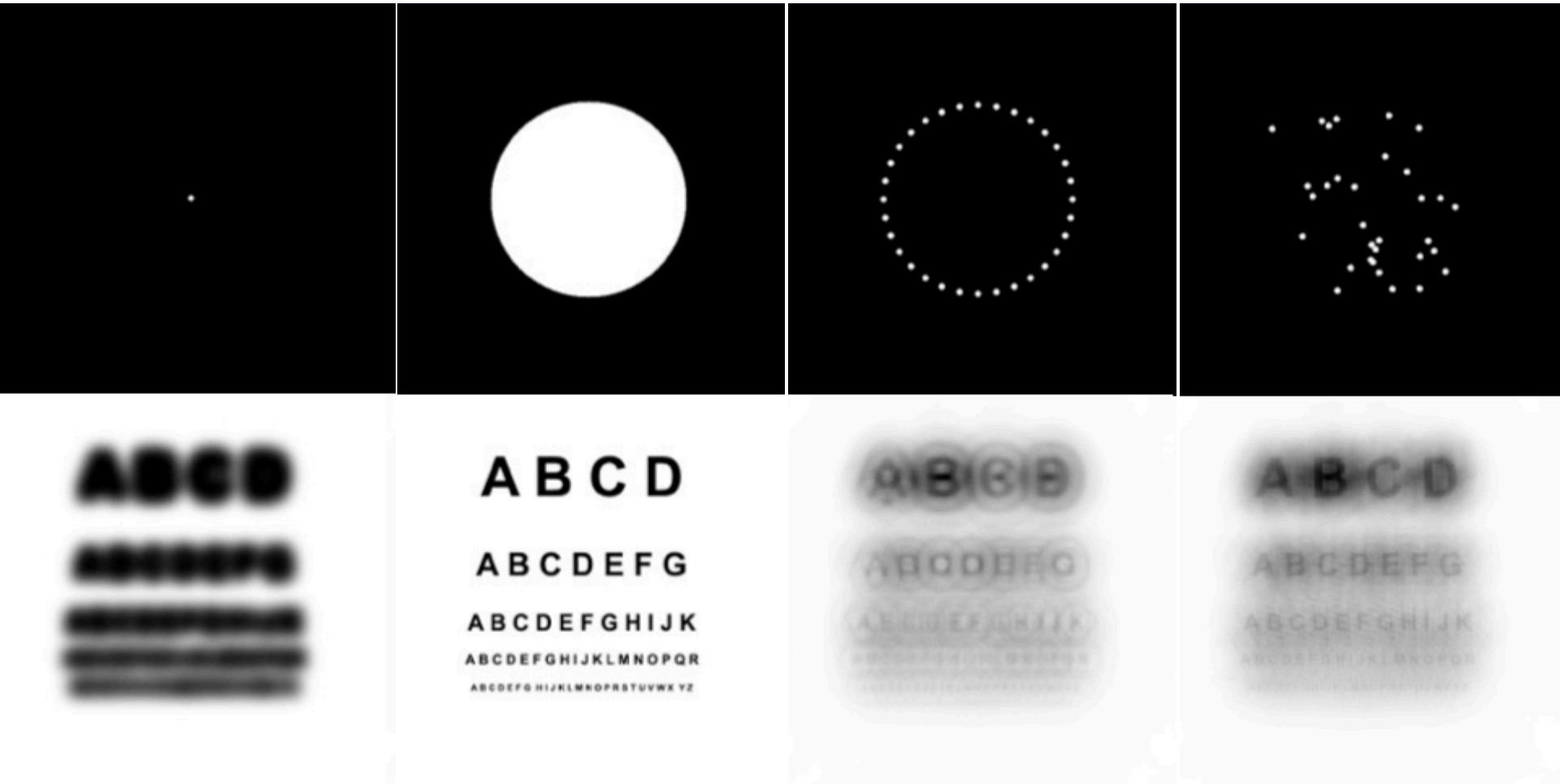
“Circular” dishes





# Interferometer – multiple dishes

“Random” dishes



# Interferometers as spatial filters

... a bit of equations (Fourier Transform)

$$V(u, v) = \iint I(l, m) e^{2\pi i(ul + vm)} dl dm$$

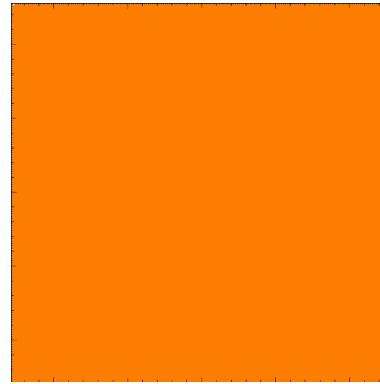
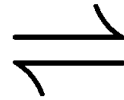
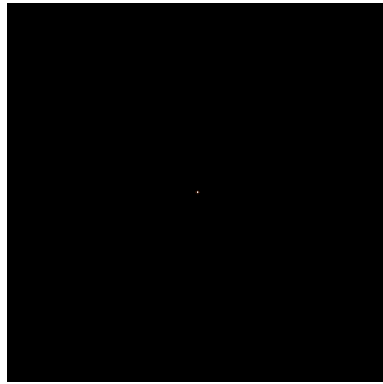
# Interferometers as spatial filters

... a bit of equations (Fourier Transform)

$$V(u, v) = \int \int I(l, m) e^{2\pi i(ul + vm)} dl dm$$

$I(l, m)$

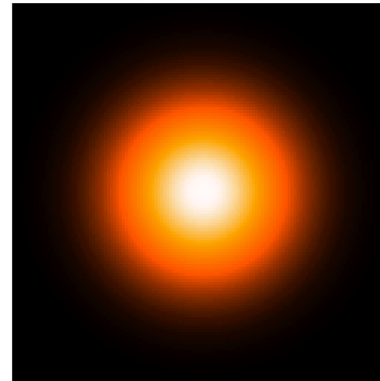
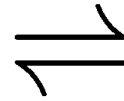
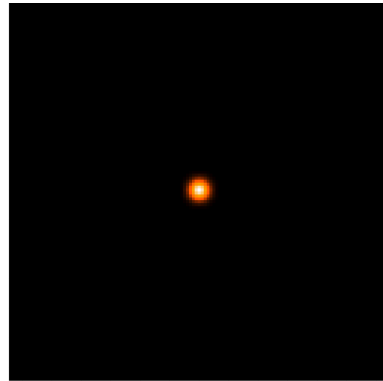
$\delta$  Function



$V(u, v)$

Constant

Gaussian



Gaussian



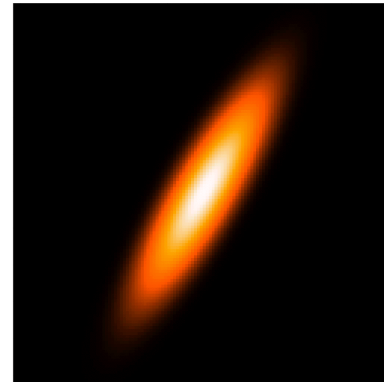
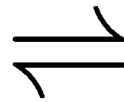
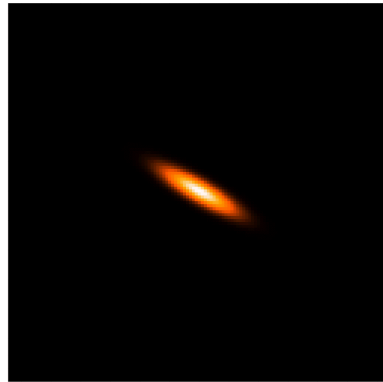
# Interferometers as spatial filters

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$I(l, m)$

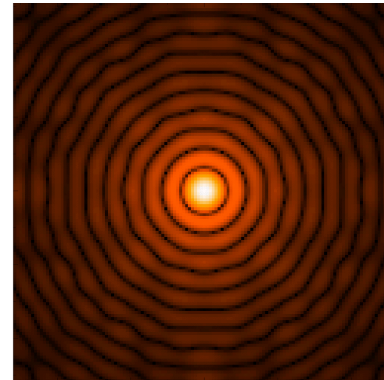
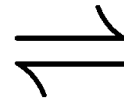
elliptical  
Gaussian



$V(u, v)$

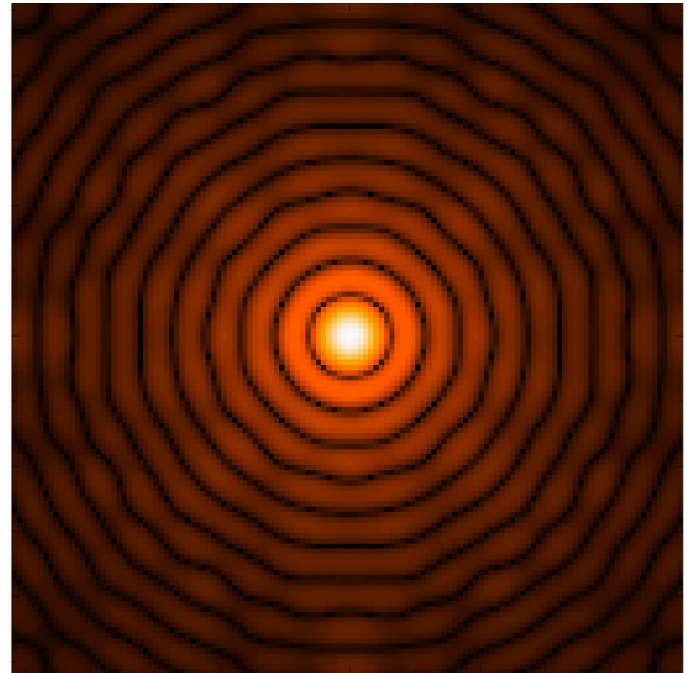
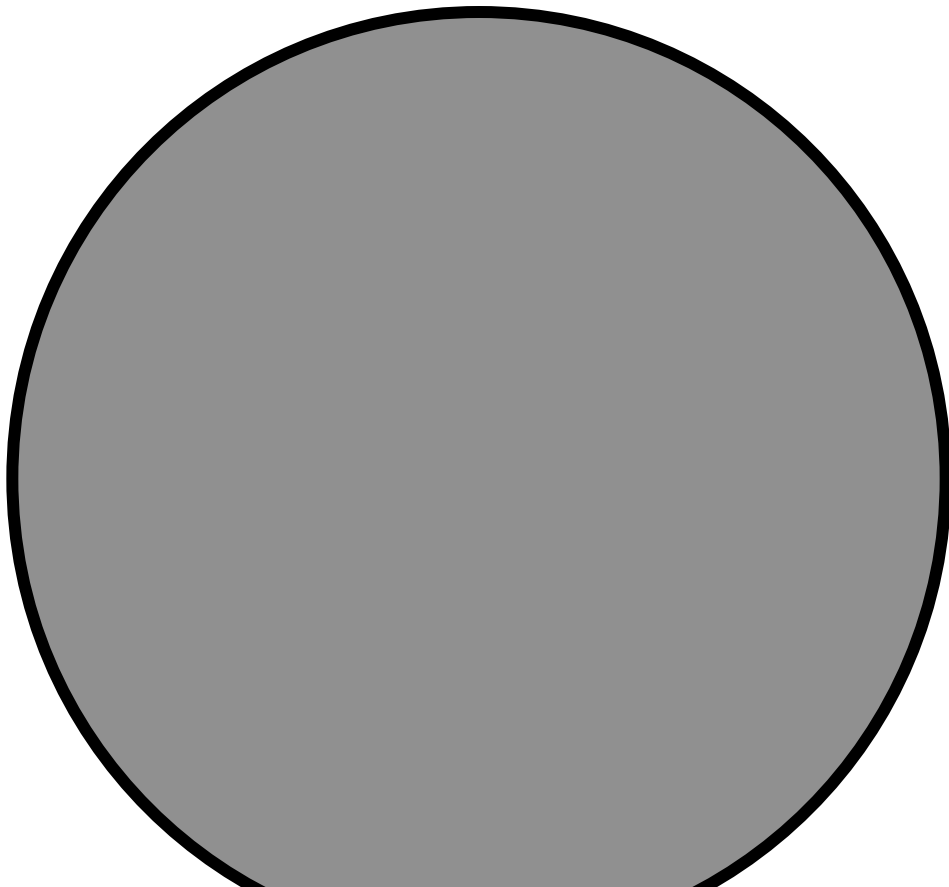
elliptical  
Gaussian

Disk

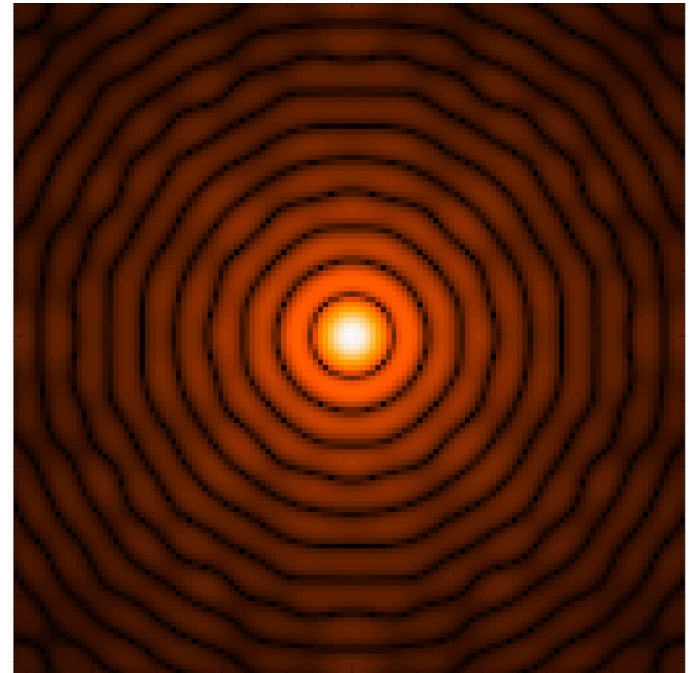
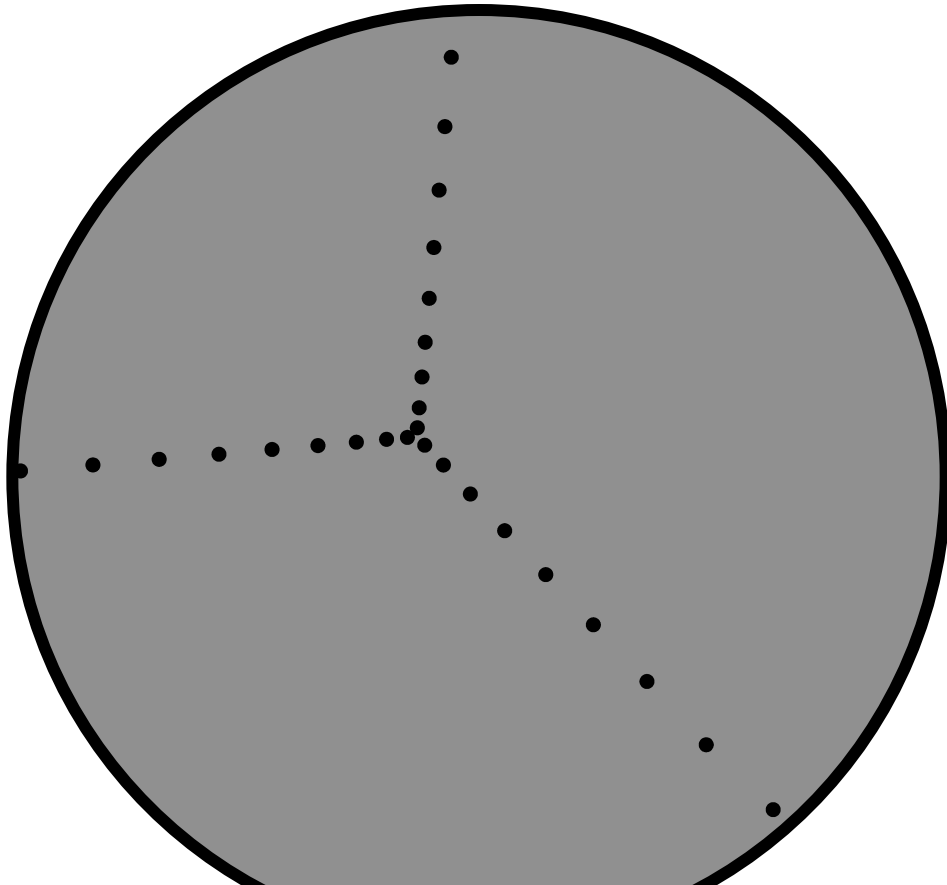


Bessel

# Interferometers as spatial filters

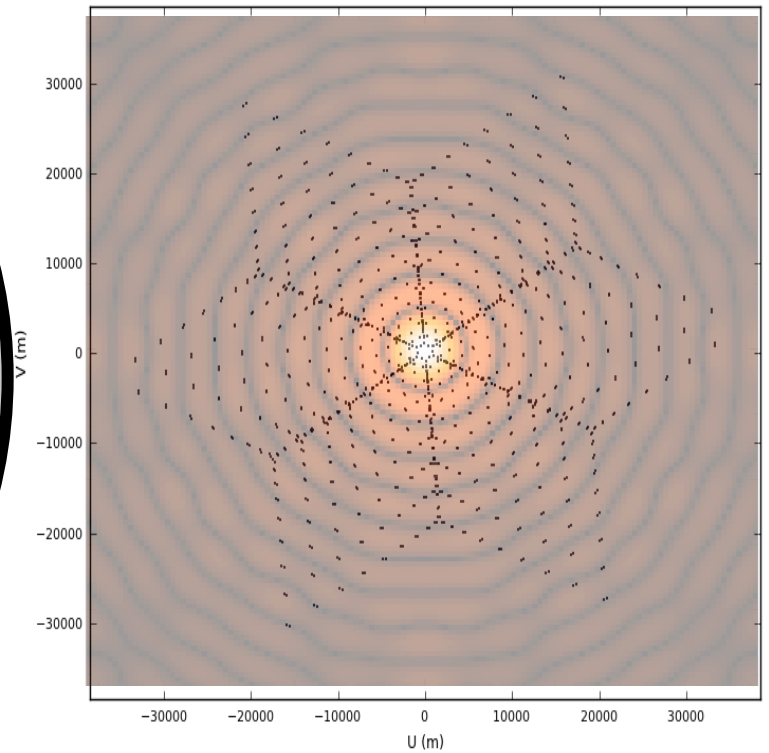
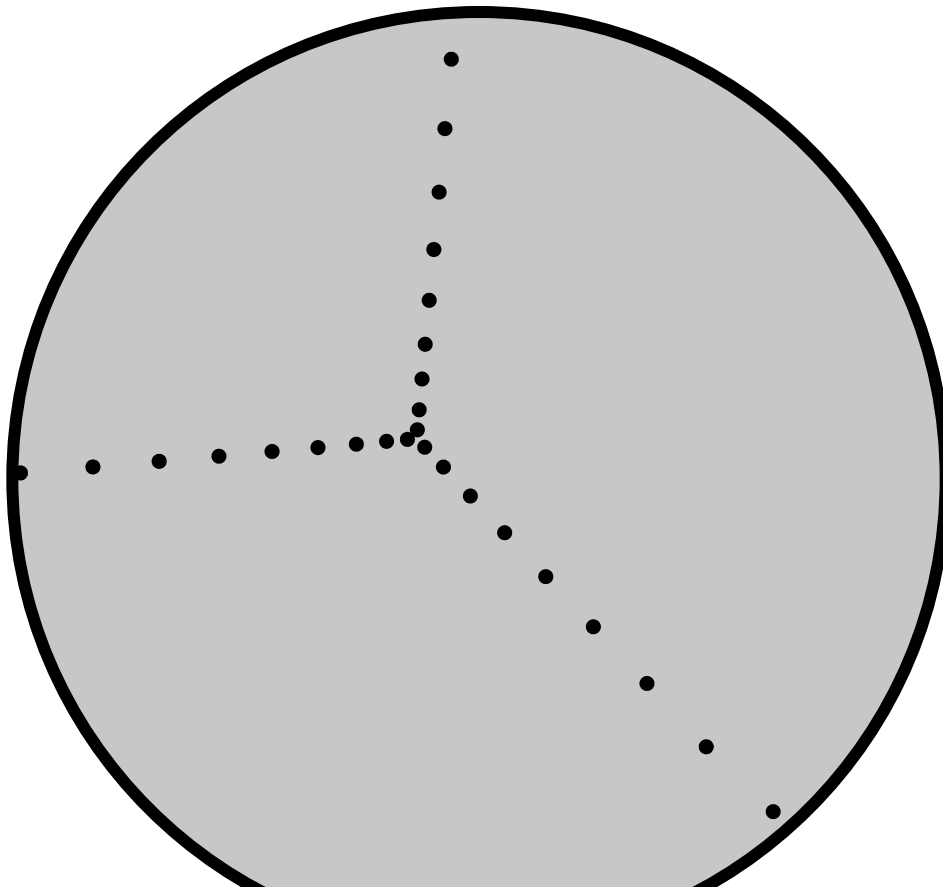


# Interferometers as spatial filters





# Interferometers as spatial filters

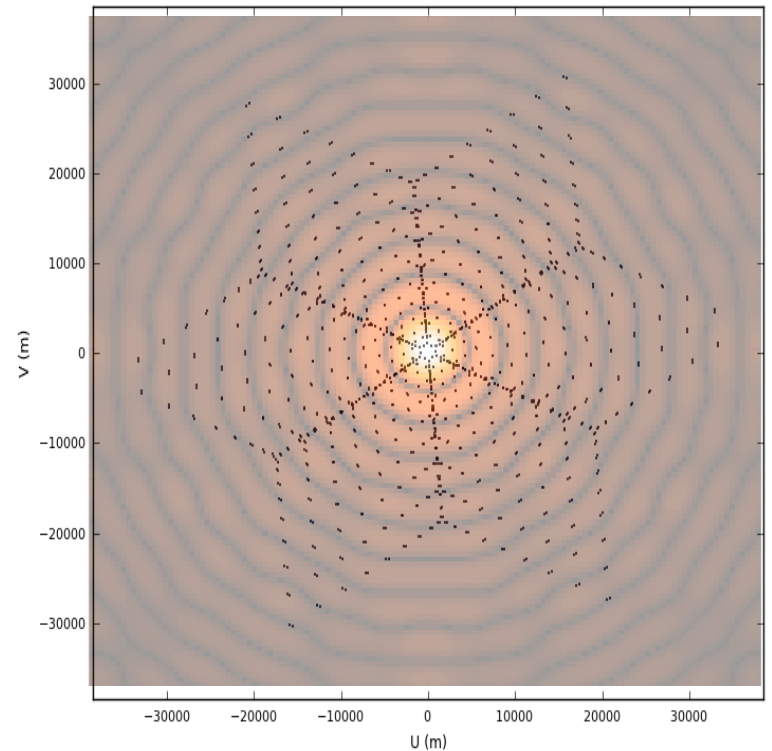
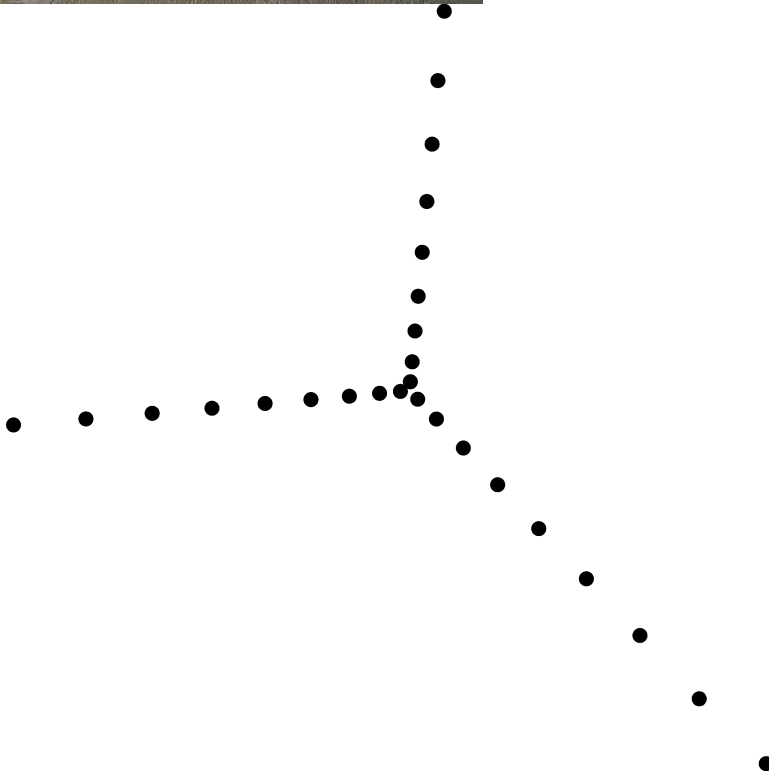


# Example: VLA



## Very Large Array (VLA)

- 27 antennas of 25 meters (diameter)
- observing from cm to mm wavelengths
- in New Mexico (USA)



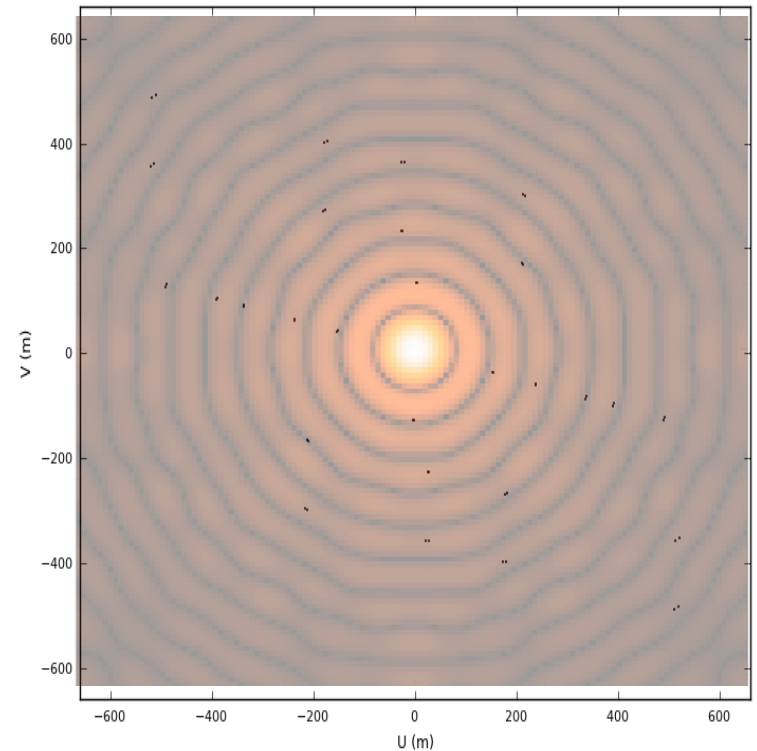
# Example: PdBI



## Plateau de Bure Interferometer (PdBI)

- 6 antennas of 15 meters (diameter)
- observing from mm to submm
- in Grenoble (France)

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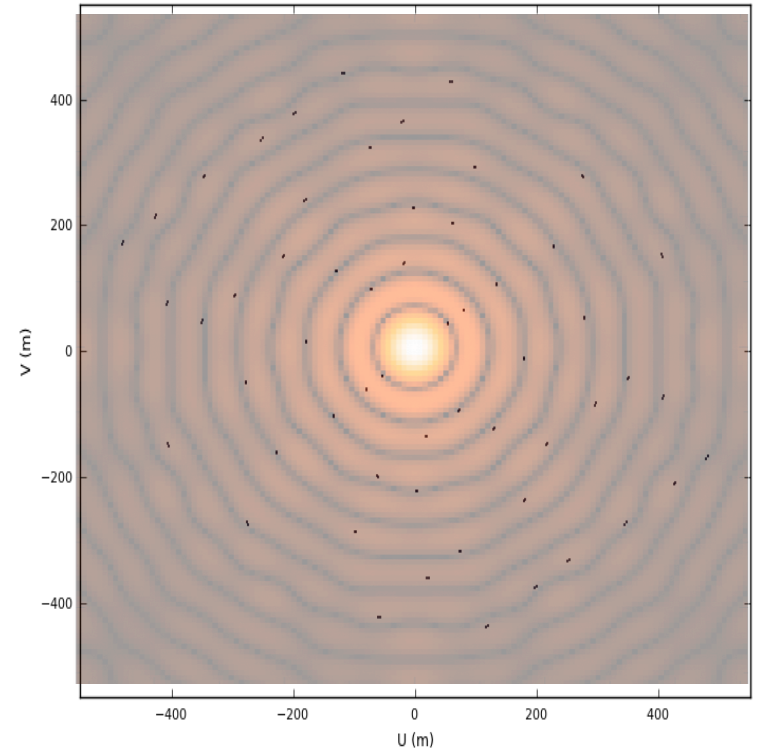
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# Example: SMA



## SubMillimeter Array (SMA)

- 8 antennas of 6 meters (diameter)
- observing from mm to submm
- in Hawaii (USA)



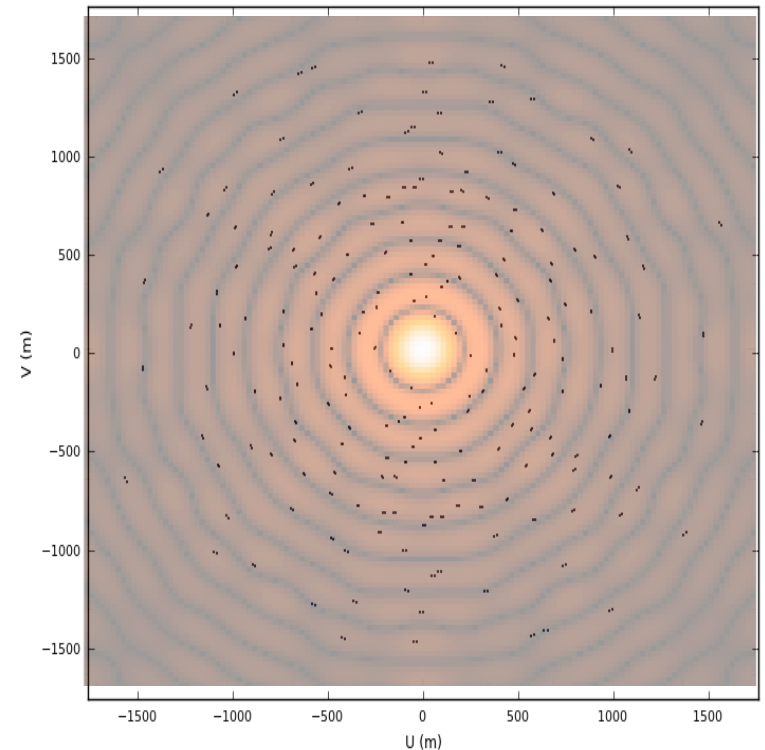


# Example: CARMA



## Combined Array for Research in mm Astro (CARMA)

- 23 antennas of 10.4/6.1/3.5 meters
- observing from cm to mm wavelengths
- in California (USA)

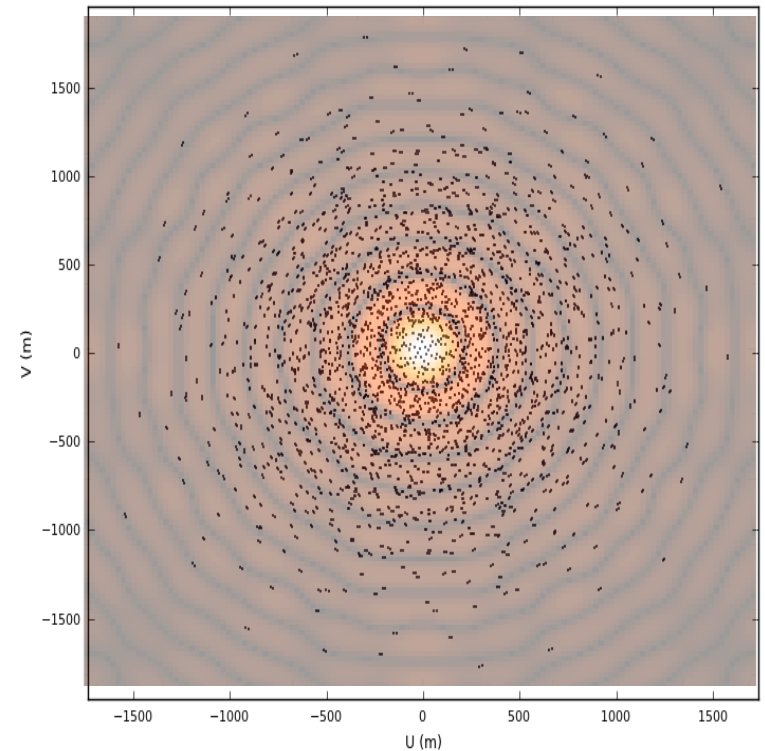
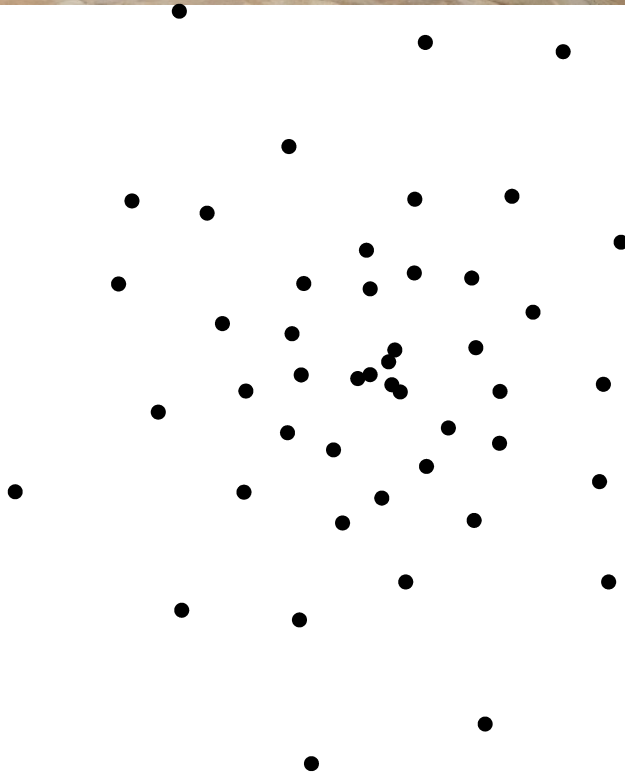


# Example: ALMA



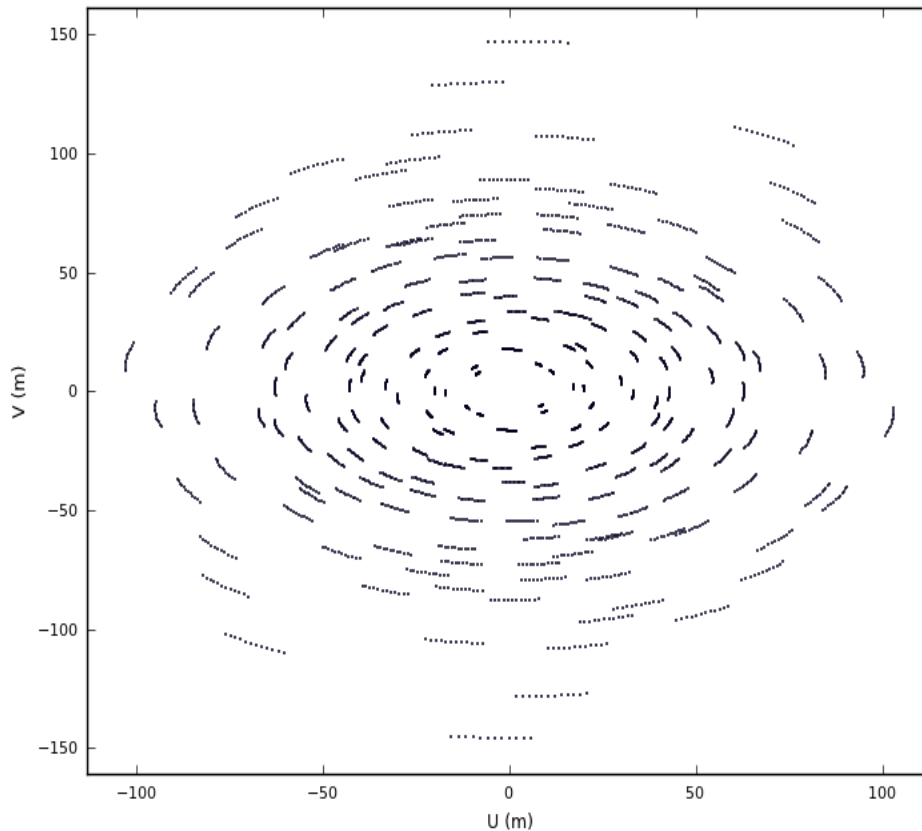
## Atacama Large mm/submm Array (ALMA)

- 50 antennas of 12/7 meters
- observing from mm to submm
- in Llano Chajnantor (Chile)



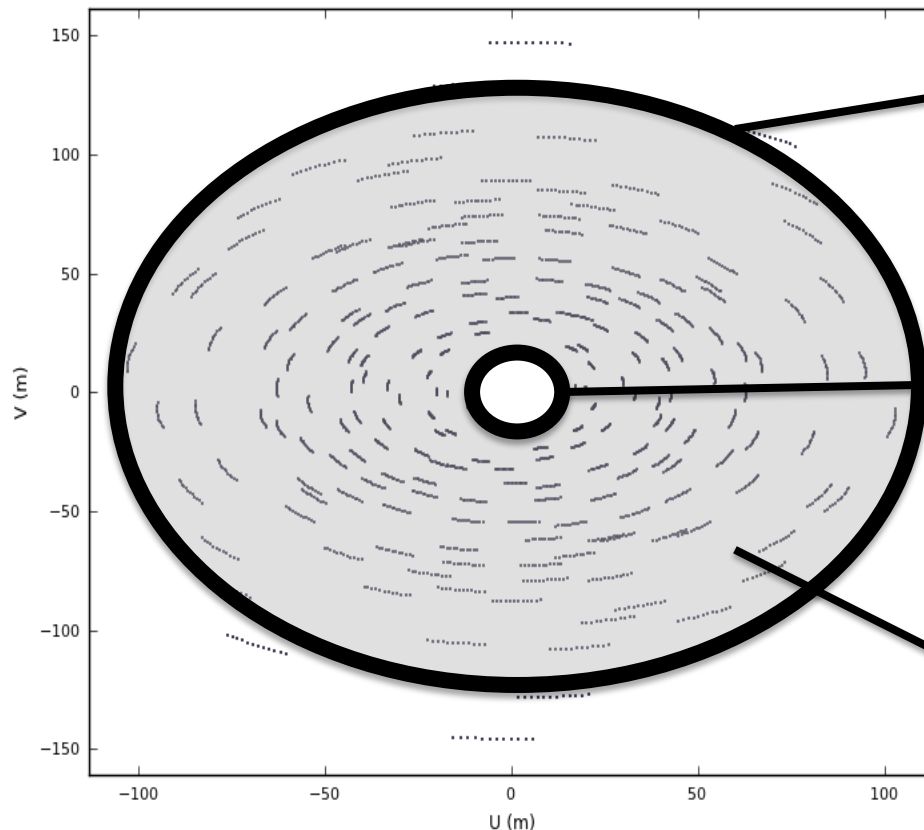
# Interferometers as spatial filters

- samples of  $V(u,v)$  are limited by the number of telescopes, and the Earth-sky geometry



# Interferometers as spatial filters

- samples of  $V(u,v)$  are limited by the number of telescopes, and the Earth-sky geometry



**outer boundary:**

- no small scales
- resolution limit

**inner hole:**

- no large scales
- extended structures

**irregular coverage:**

- information missing



# Primary beam, synthesized beam, and LAS

**PRIMARY BEAM**



**SYNTHESIZED BEAM**

**LARGEST ANGULAR SCALE**

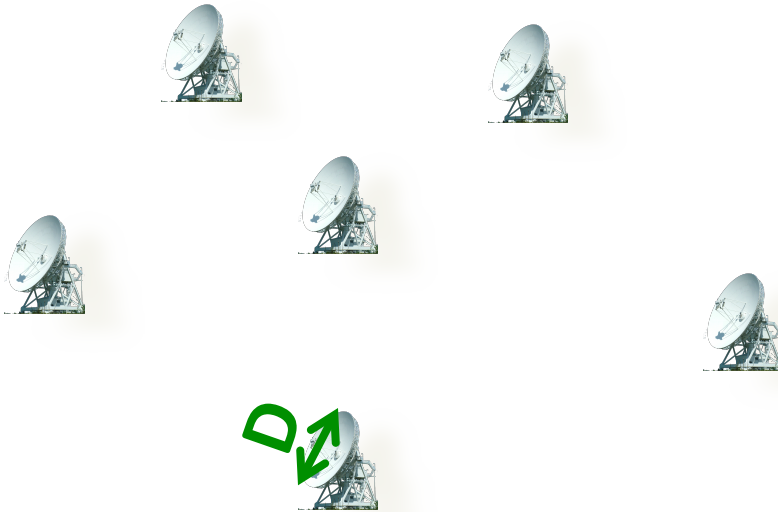
# Primary beam, synthesized beam, and LAS

**PRIMARY BEAM**

$$PB = 1.22 \frac{\lambda}{D}$$

**SYNTHESIZED BEAM**

**LARGEST ANGULAR SCALE**



# Primary beam, synthesized beam, and LAS

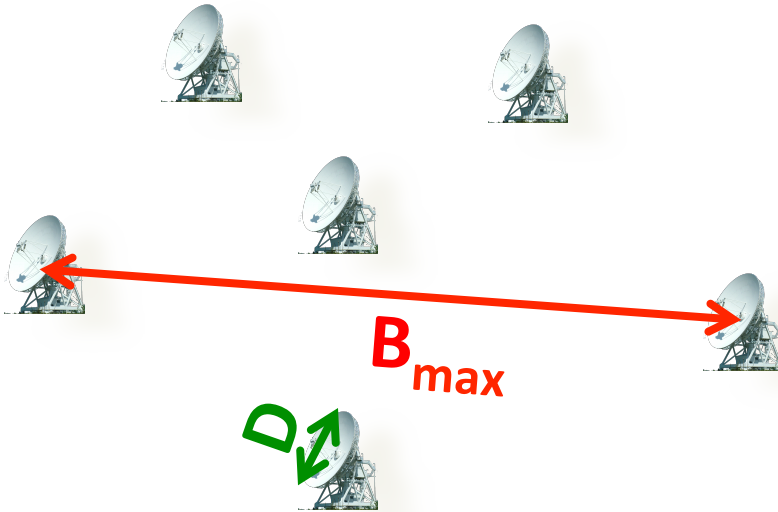
## PRIMARY BEAM

$$PB = 1.22 \frac{\lambda}{D}$$

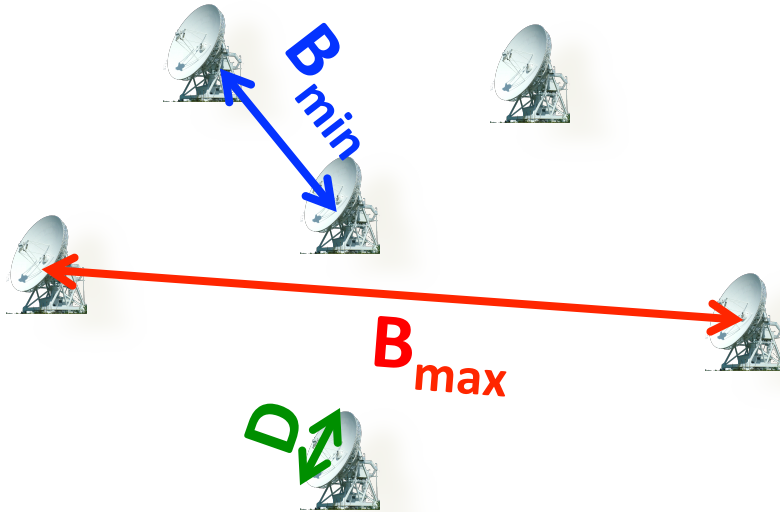
## SYNTHESIZED BEAM

$$\theta_{beam} = 1.22 \frac{\lambda}{B_{max}}$$

## LARGEST ANGULAR SCALE



# Primary beam, synthesized beam, and LAS



## PRIMARY BEAM

$$PB = 1.22 \frac{\lambda}{D}$$

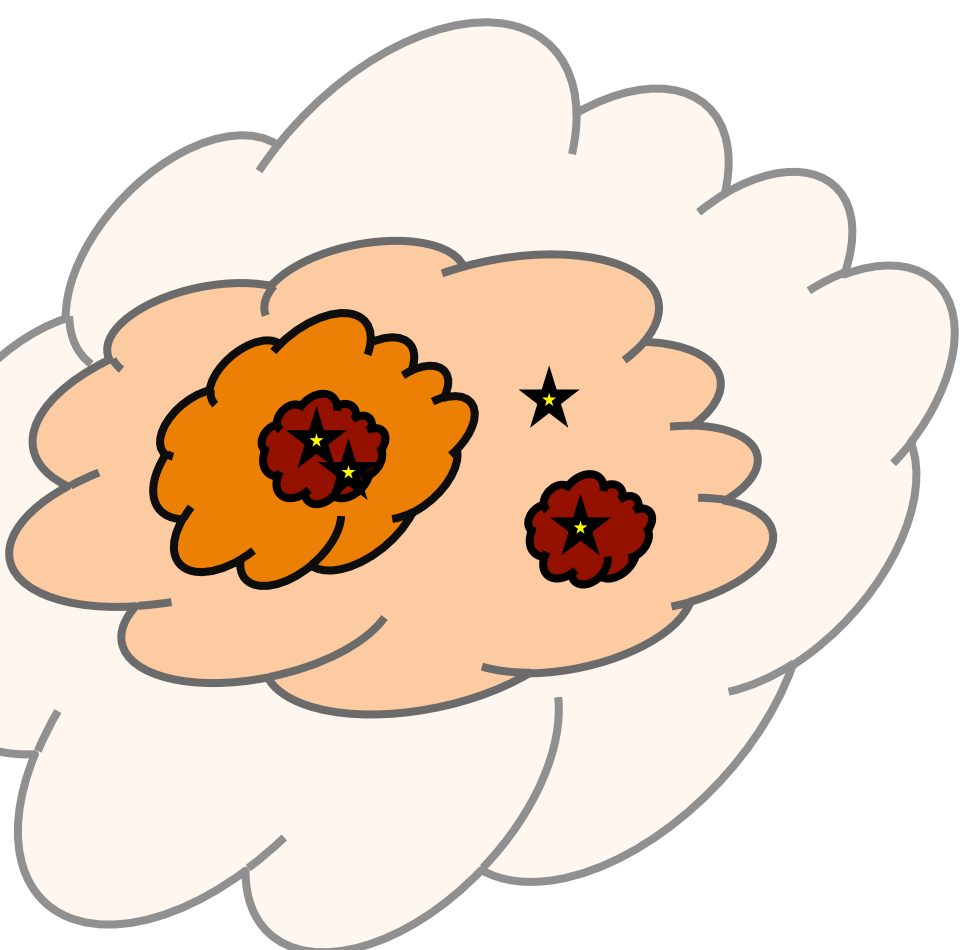
## SYNTHESIZED BEAM

$$\theta_{beam} = 1.22 \frac{\lambda}{B_{max}}$$

## LARGEST ANGULAR SCALE

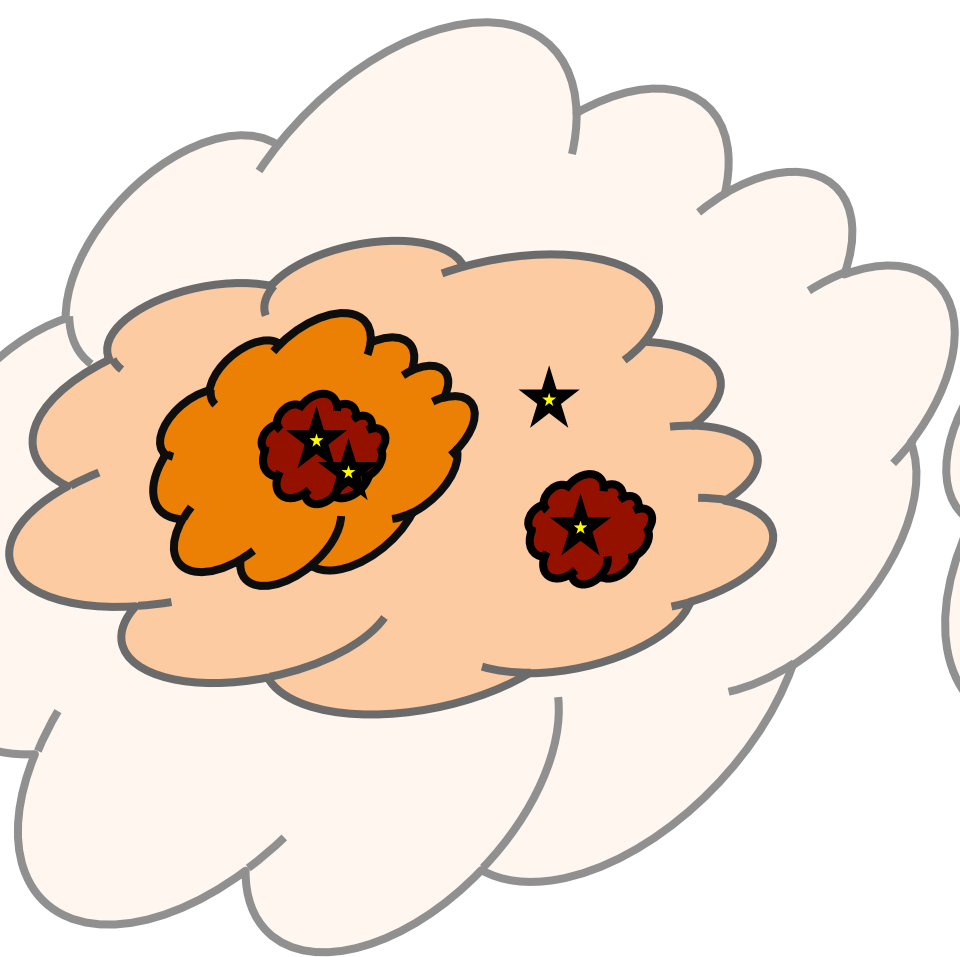
$$LAS = 1.22 \frac{\lambda}{B_{min}}$$



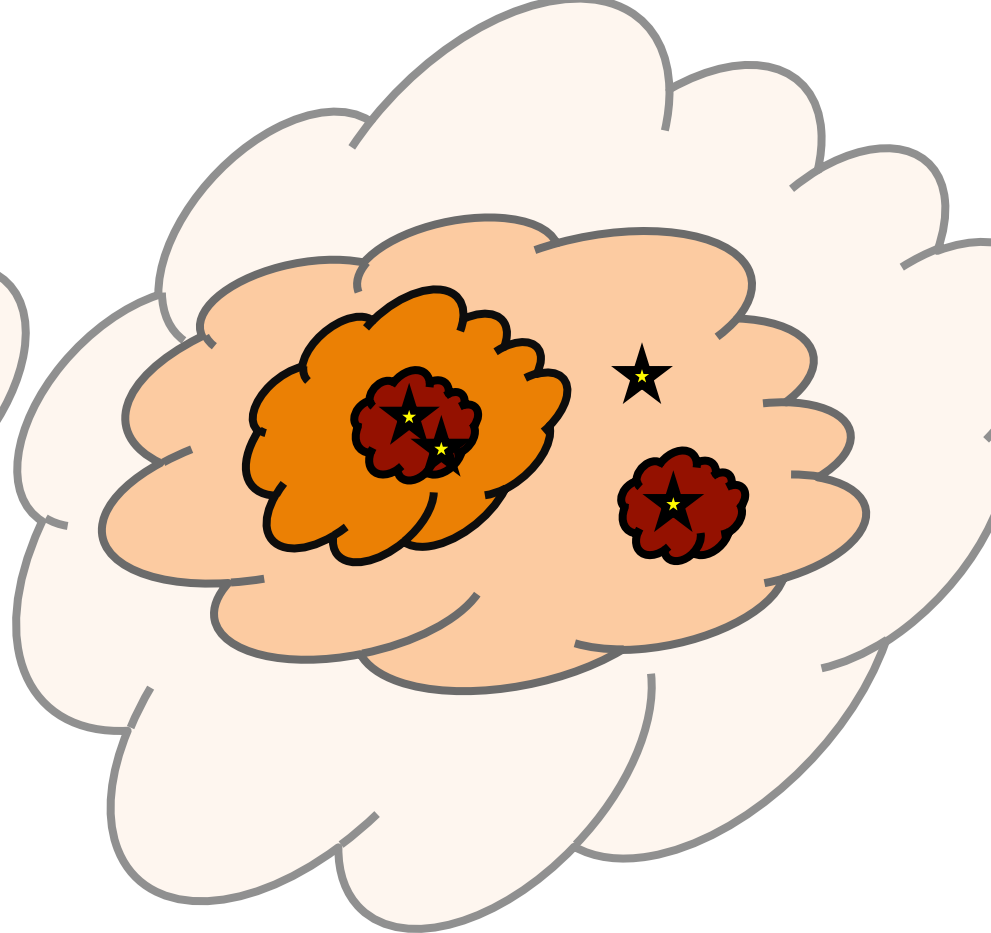


**REAL SKY**

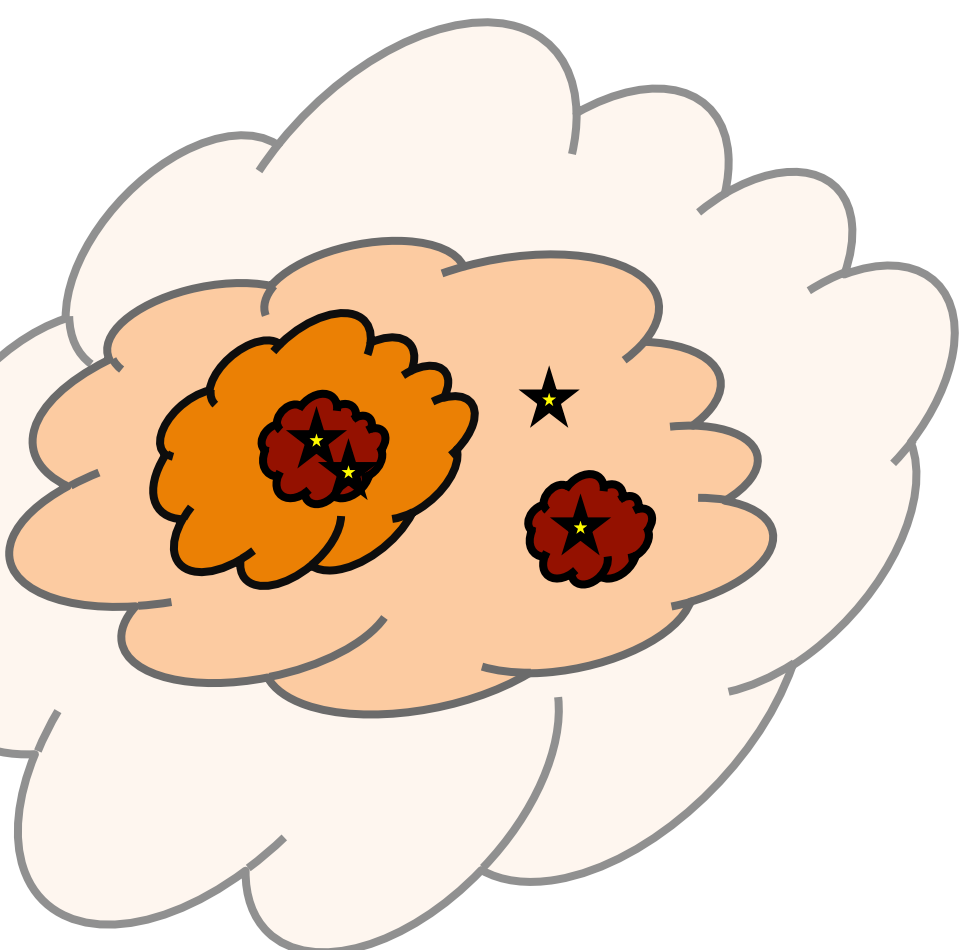




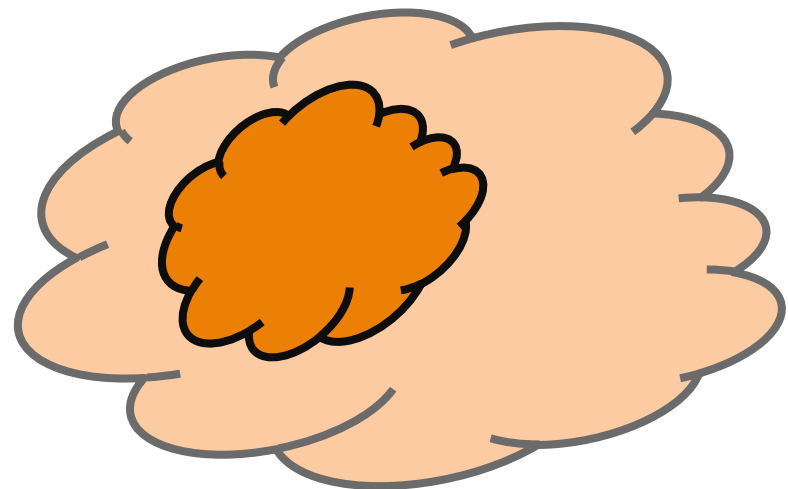
**REAL SKY**



**WHAT WE WANT TO OBTAIN**

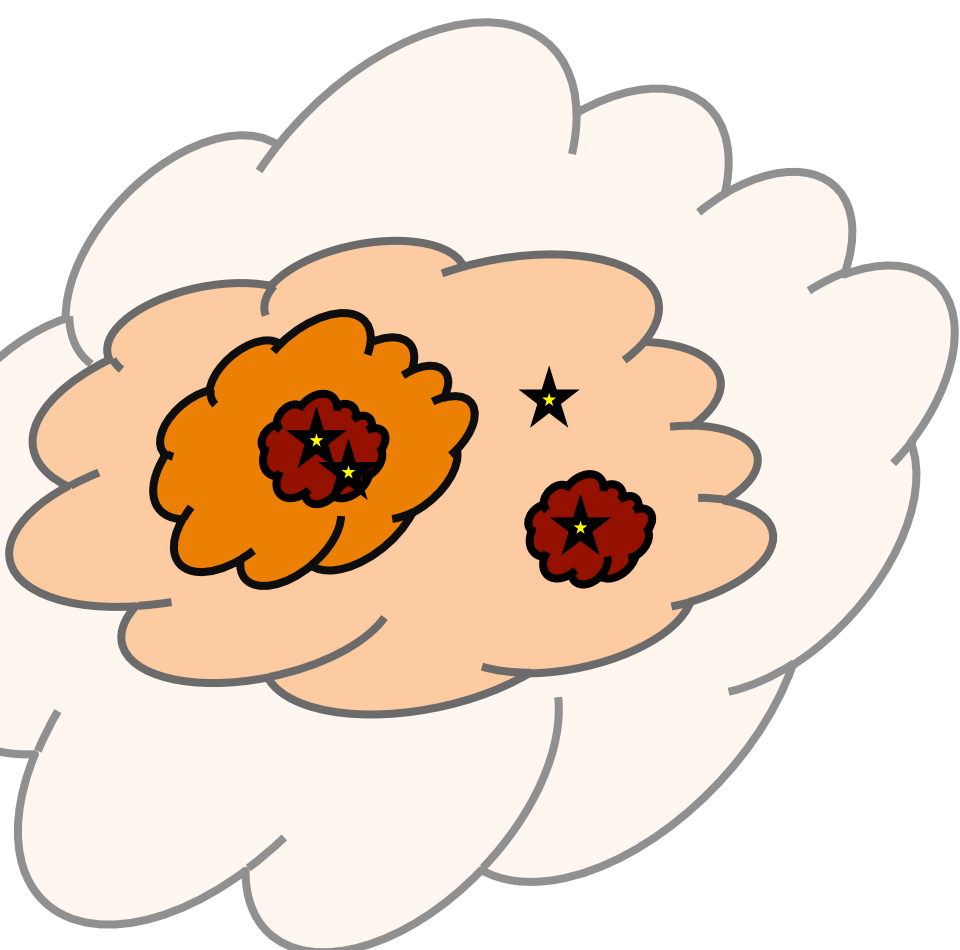


**REAL SKY**

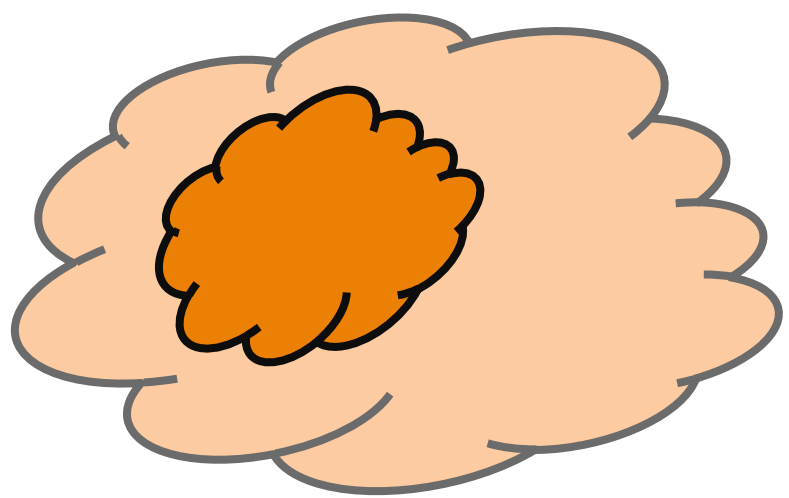


**INTERFEROMETER IMAGE**





REAL SKY

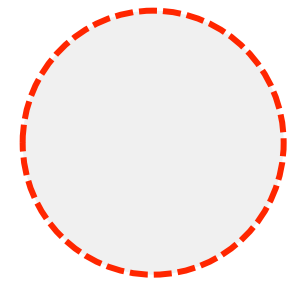


INTERFEROMETER IMAGE

$$\theta_{beam} = 1.22 \frac{\lambda}{B_{max}}$$

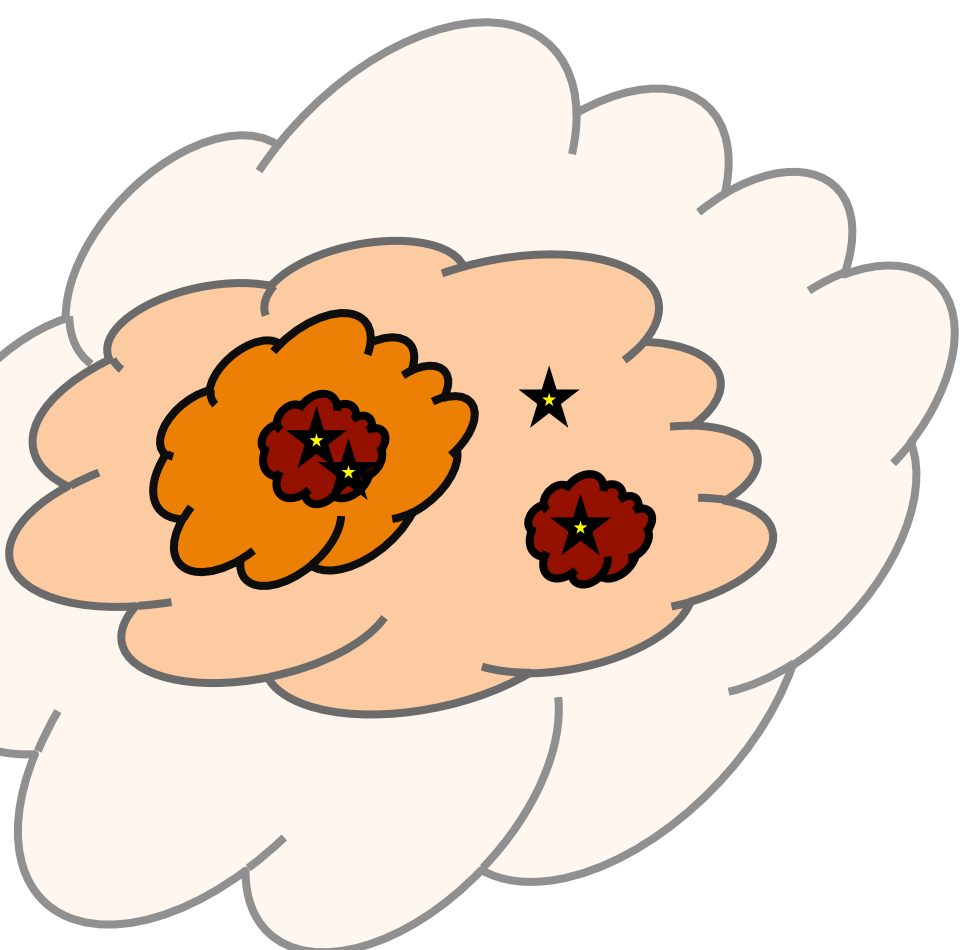


$B_{max}$

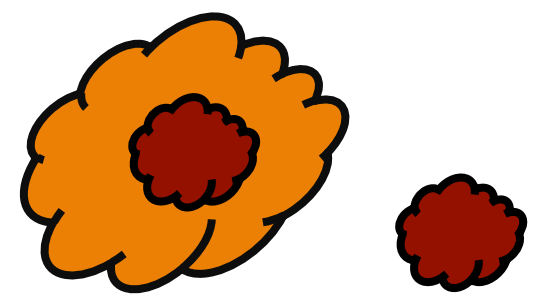


$B_{min}$

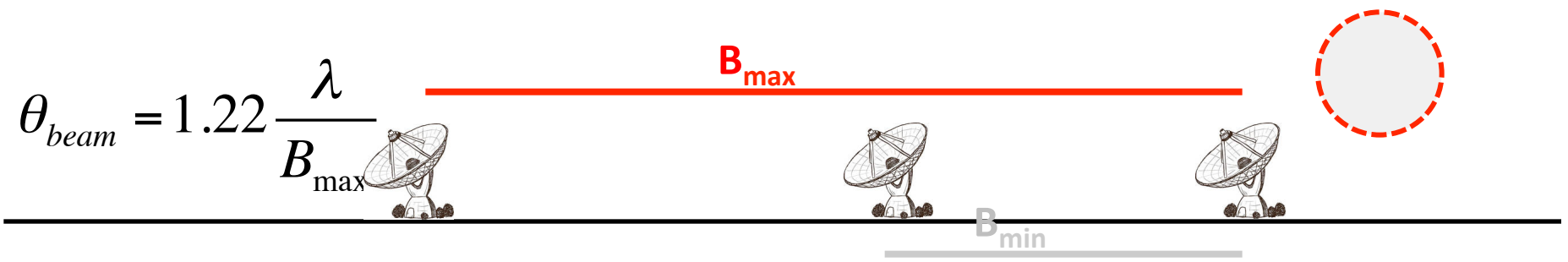




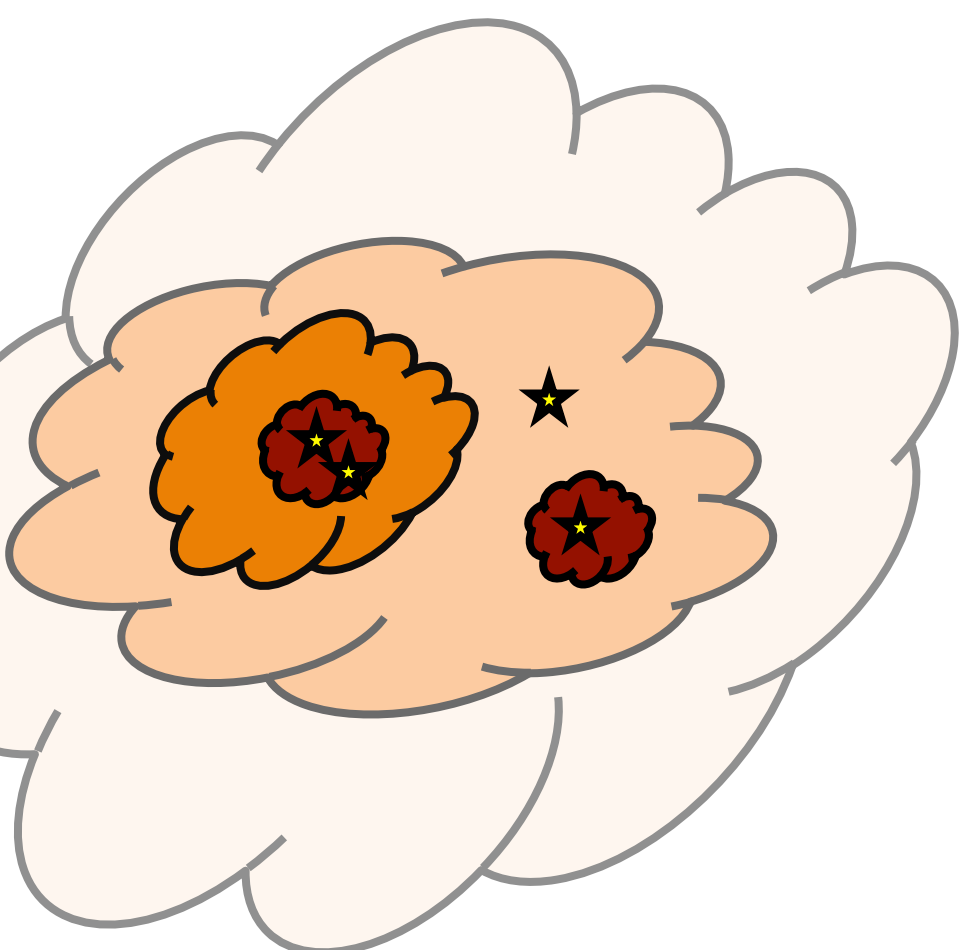
REAL SKY



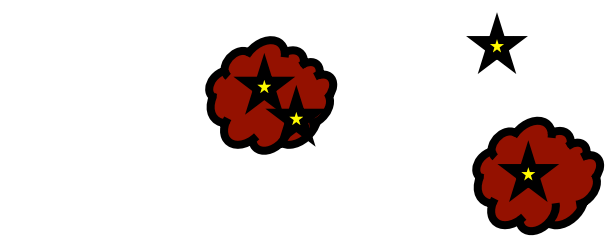
INTERFEROMETER IMAGE



$$\theta_{beam} = 1.22 \frac{\lambda}{B_{\max}}$$



REAL SKY



INTERFEROMETER IMAGE

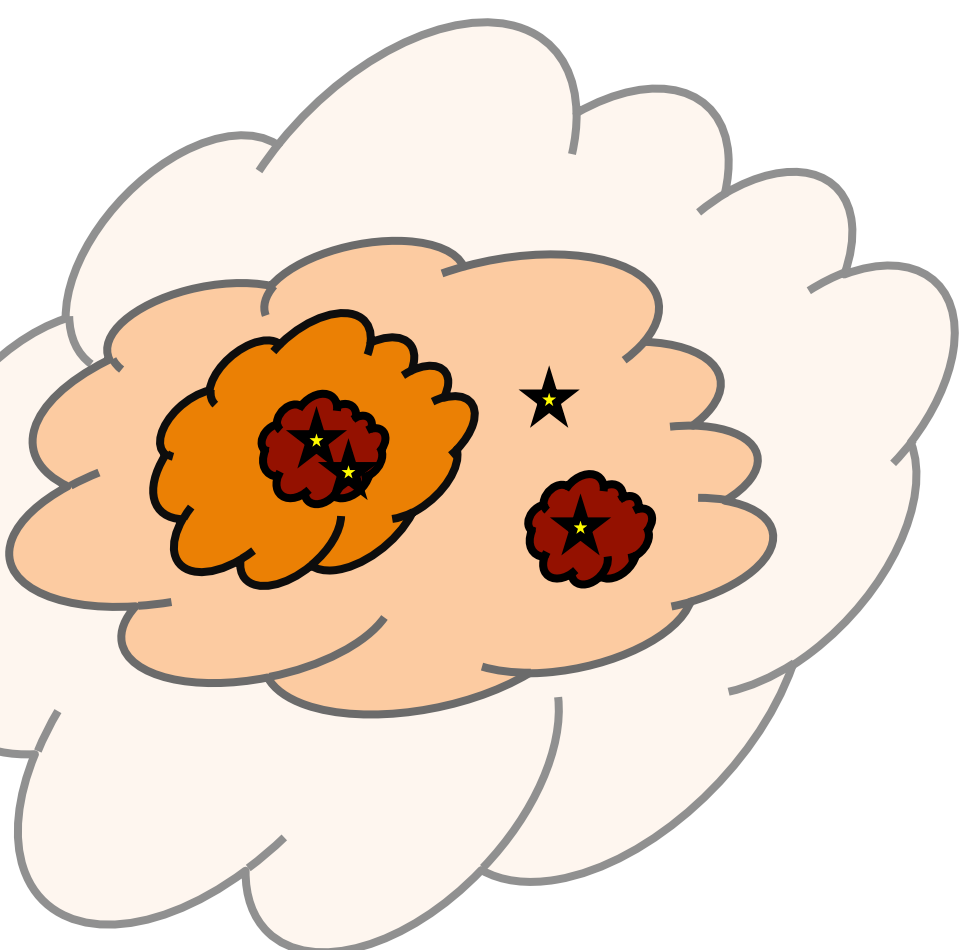
$$\theta_{be} = 1.22 \frac{\lambda}{B_{max}}$$

$B_{max}$

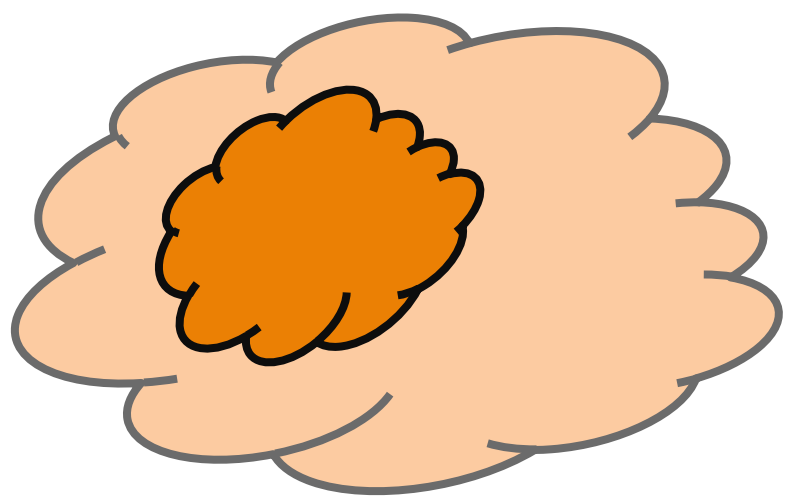


$B_{min}$





REAL SKY

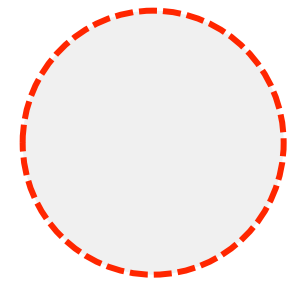


INTERFEROMETER IMAGE

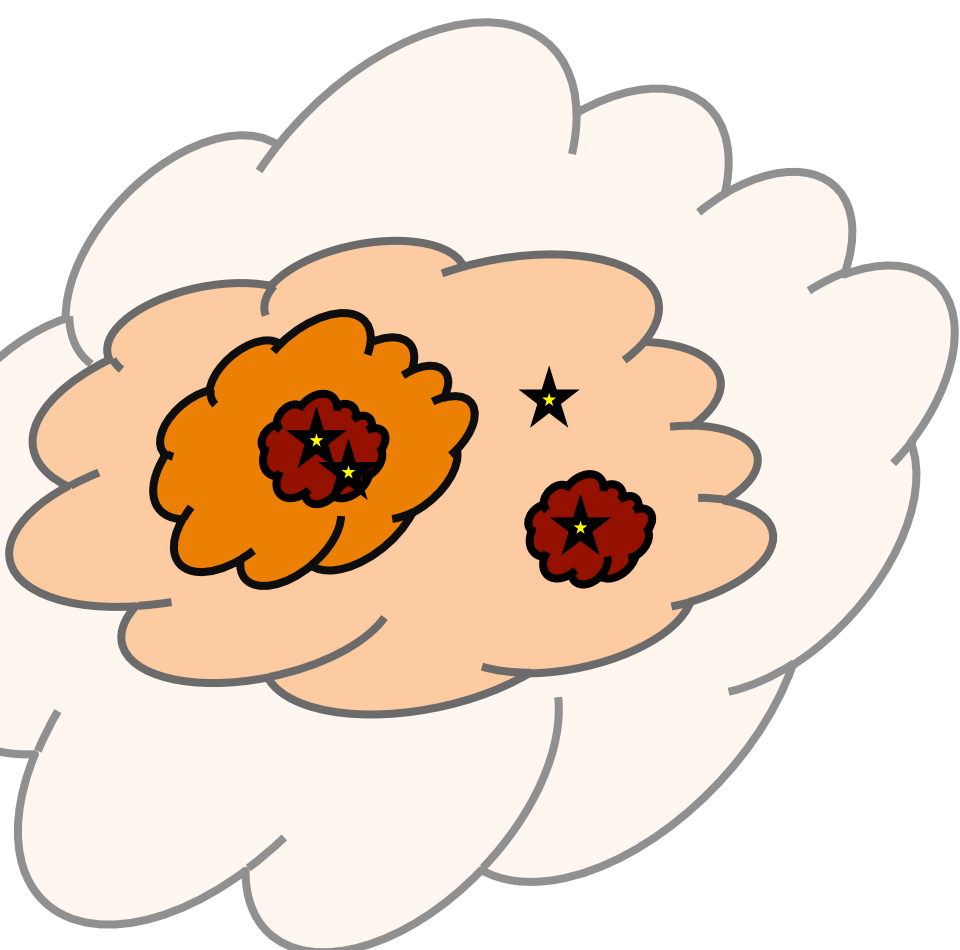
$$\theta_{beam} = 1.22 \frac{\lambda}{B_{max}}$$



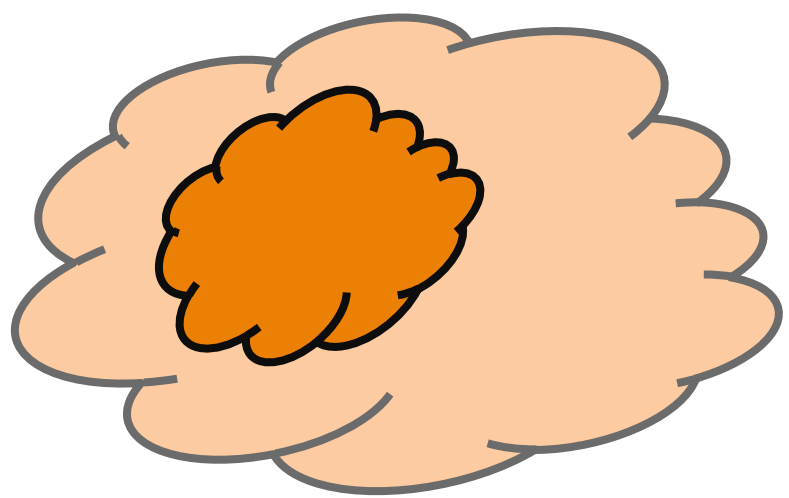
$B_{max}$



$B_{min}$

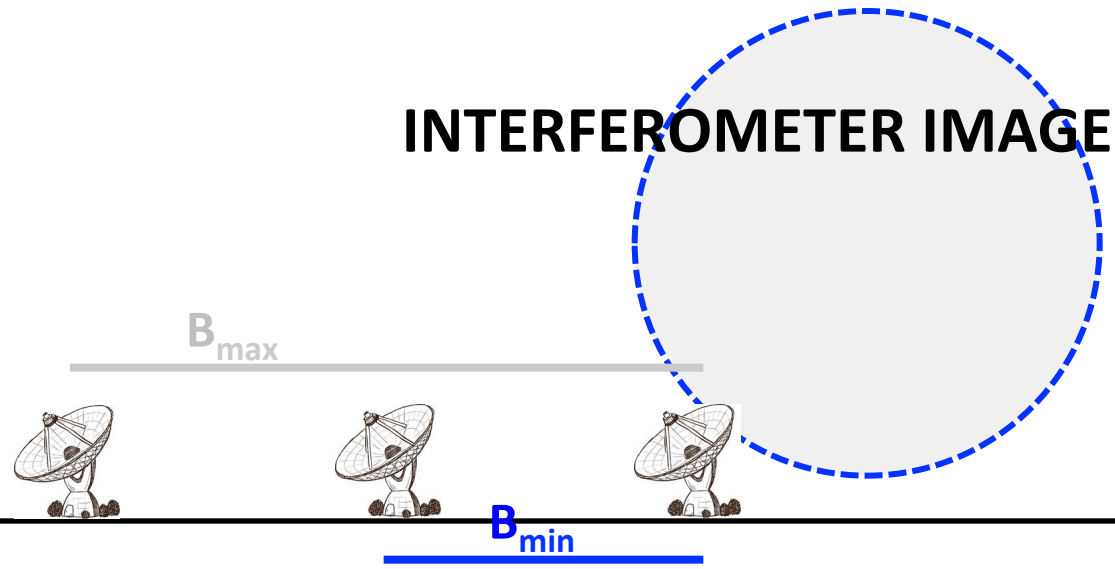


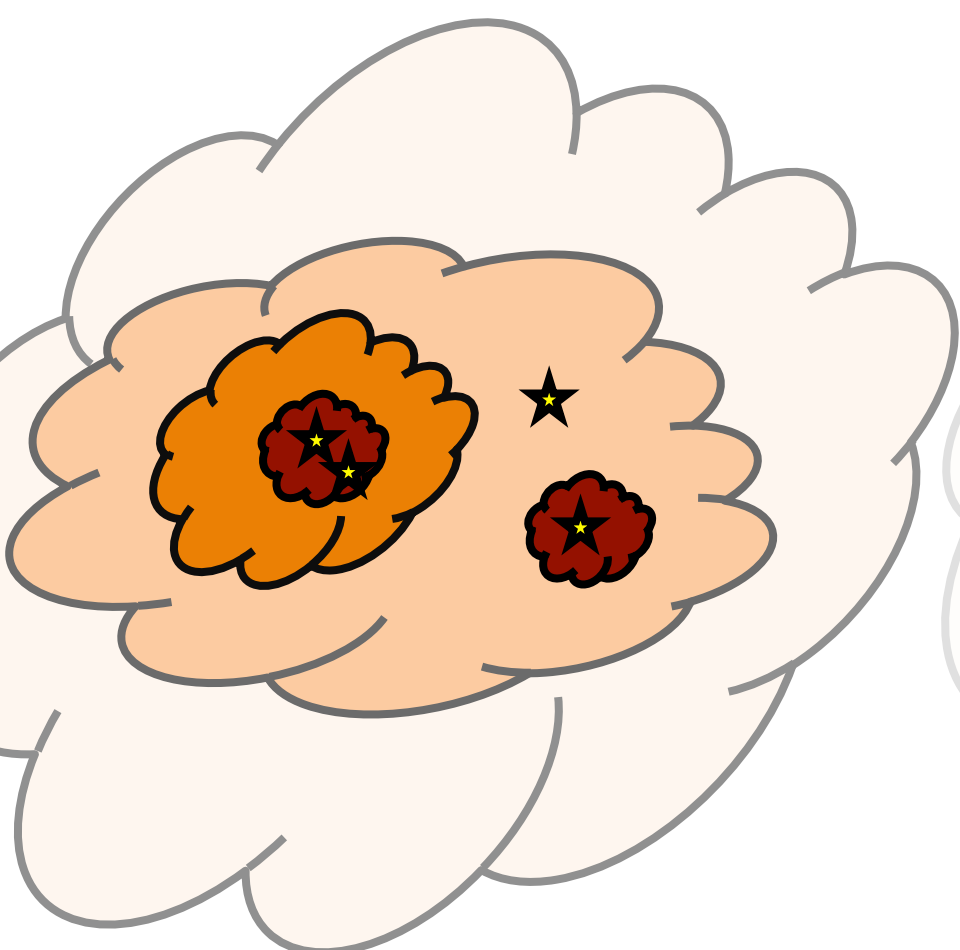
**REAL SKY**



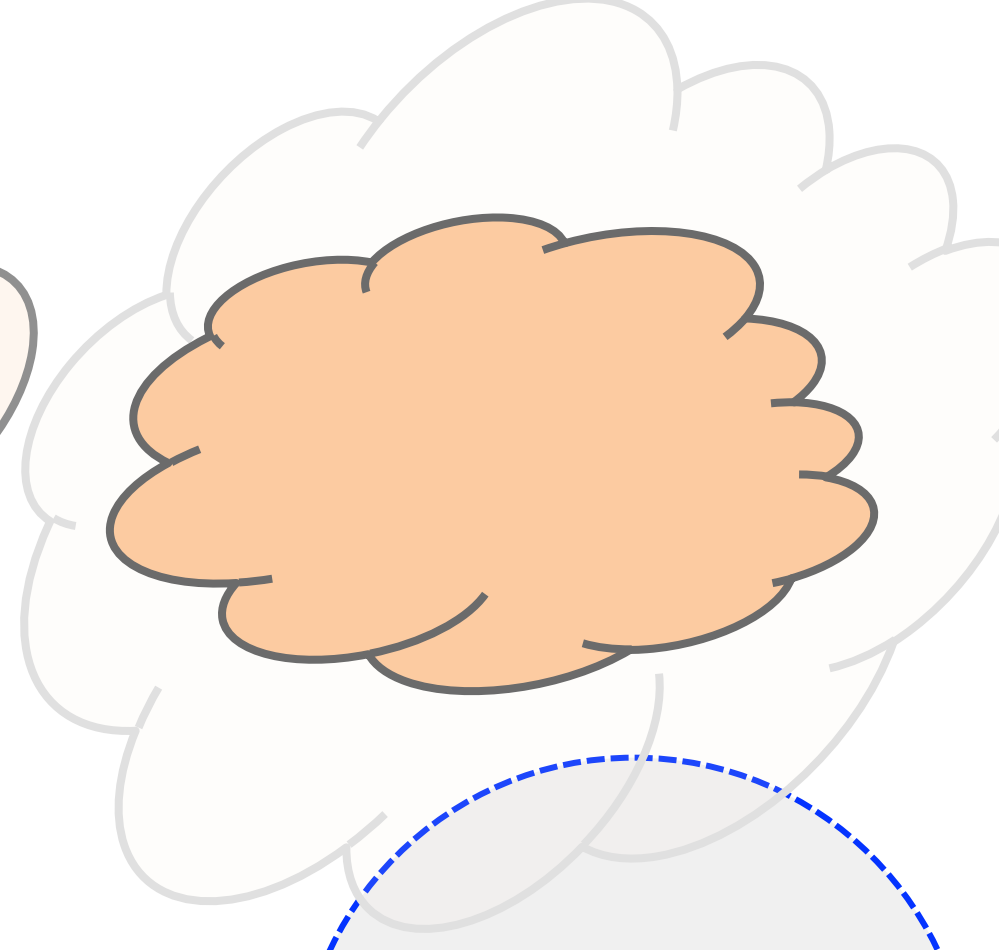
**INTERFEROMETER IMAGE**

$$LAS = 1.22 \frac{\lambda}{B_{\min}}$$



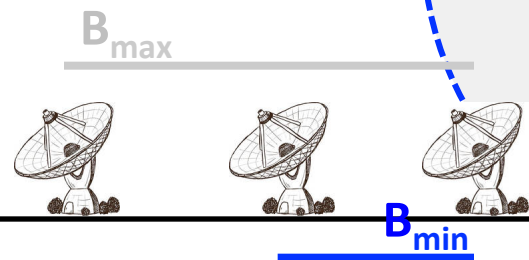


**REAL SKY**

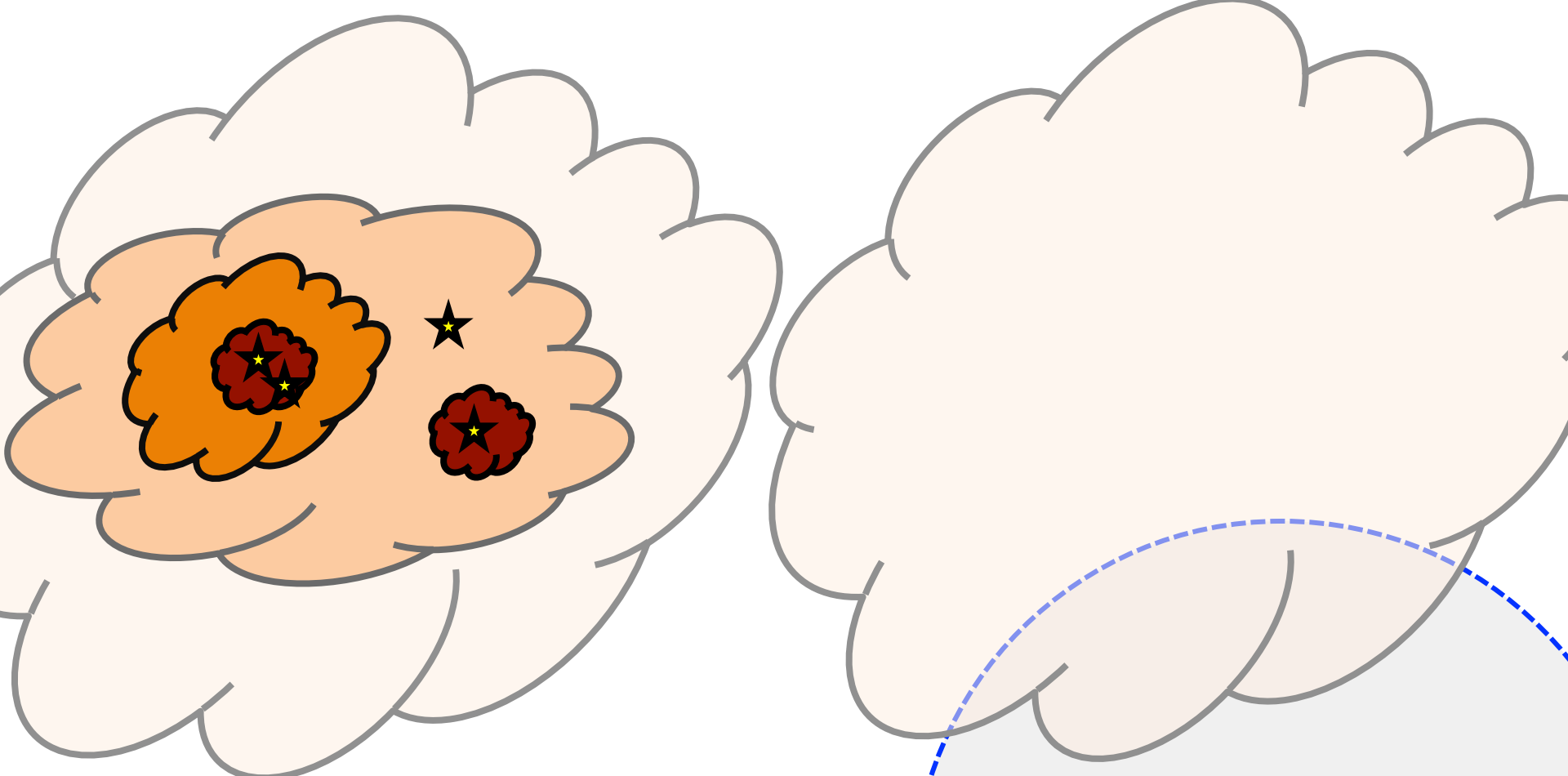


**INTERFEROMETER IMAGE**

$$LAS = 1.22 \frac{\lambda}{B_{\min}}$$



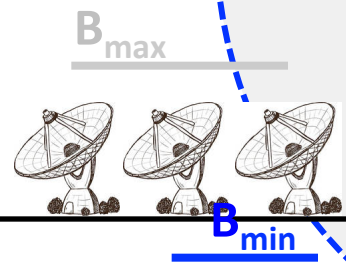


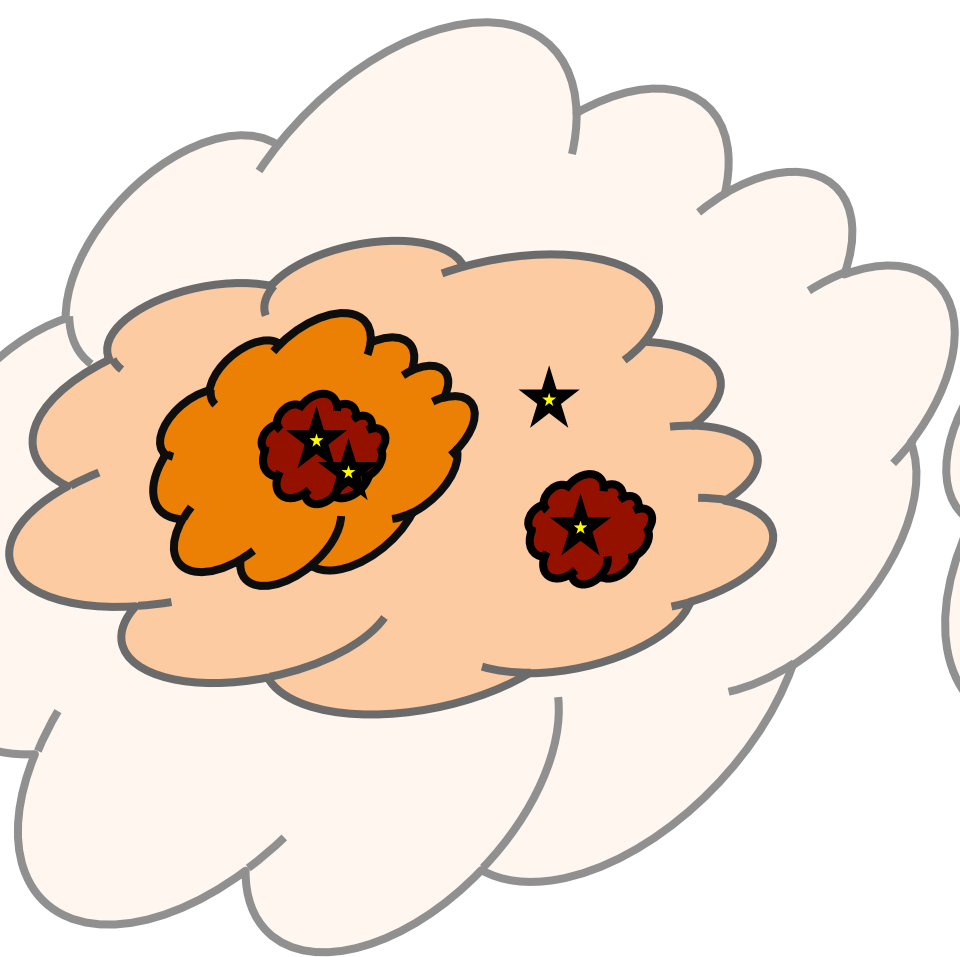


**REAL SKY**

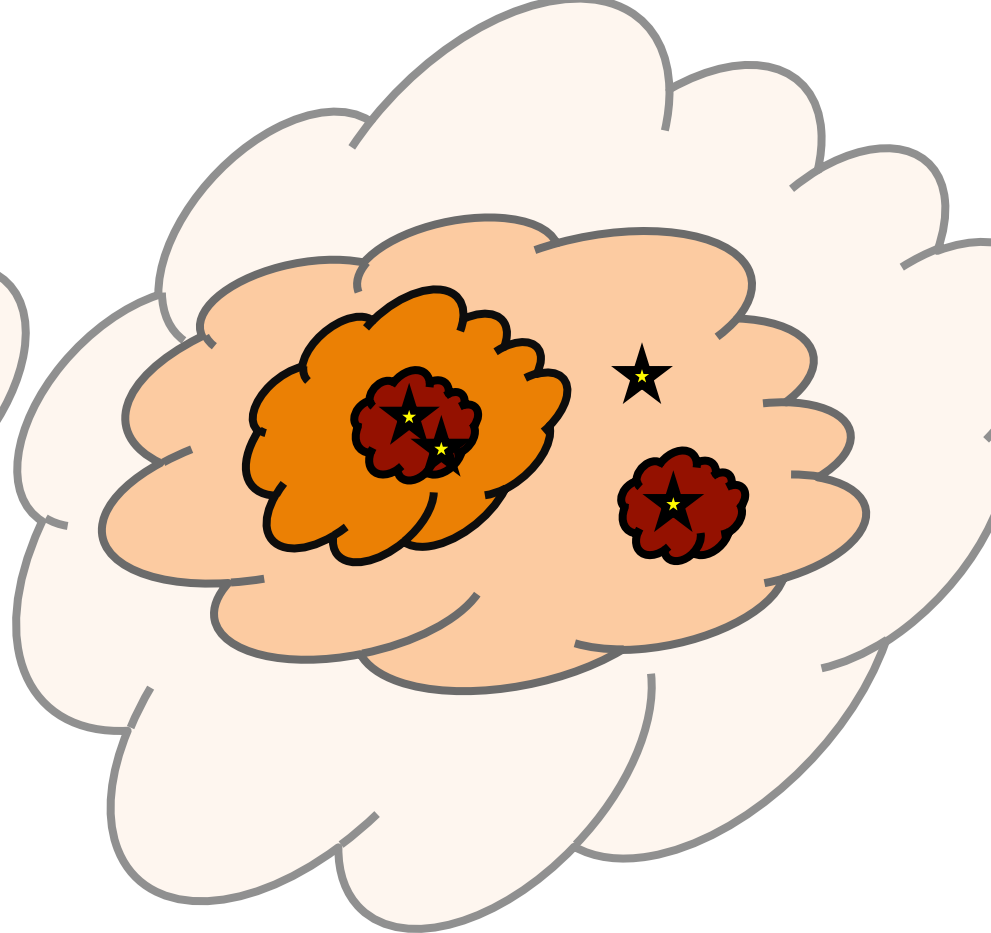
**INTERFEROMETER IMAGE**

$$LAS = 1.22 \frac{\lambda}{B_{\min}}$$



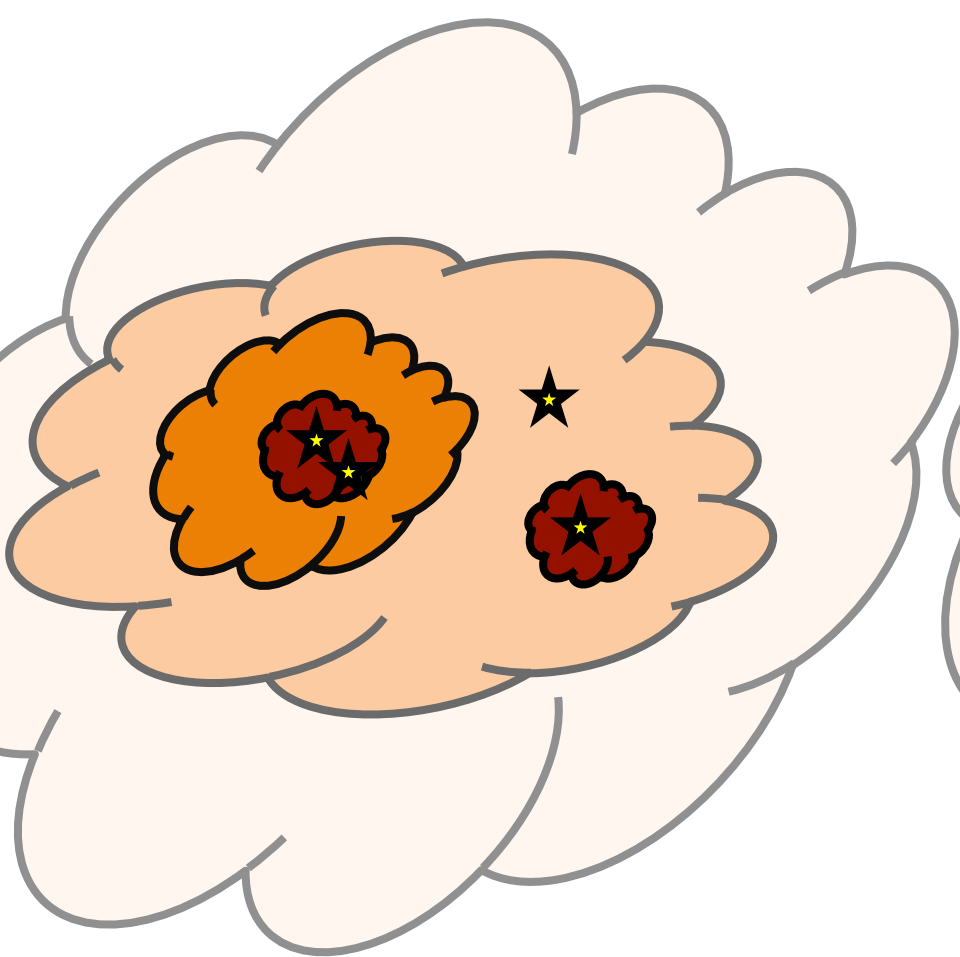


**REAL SKY**



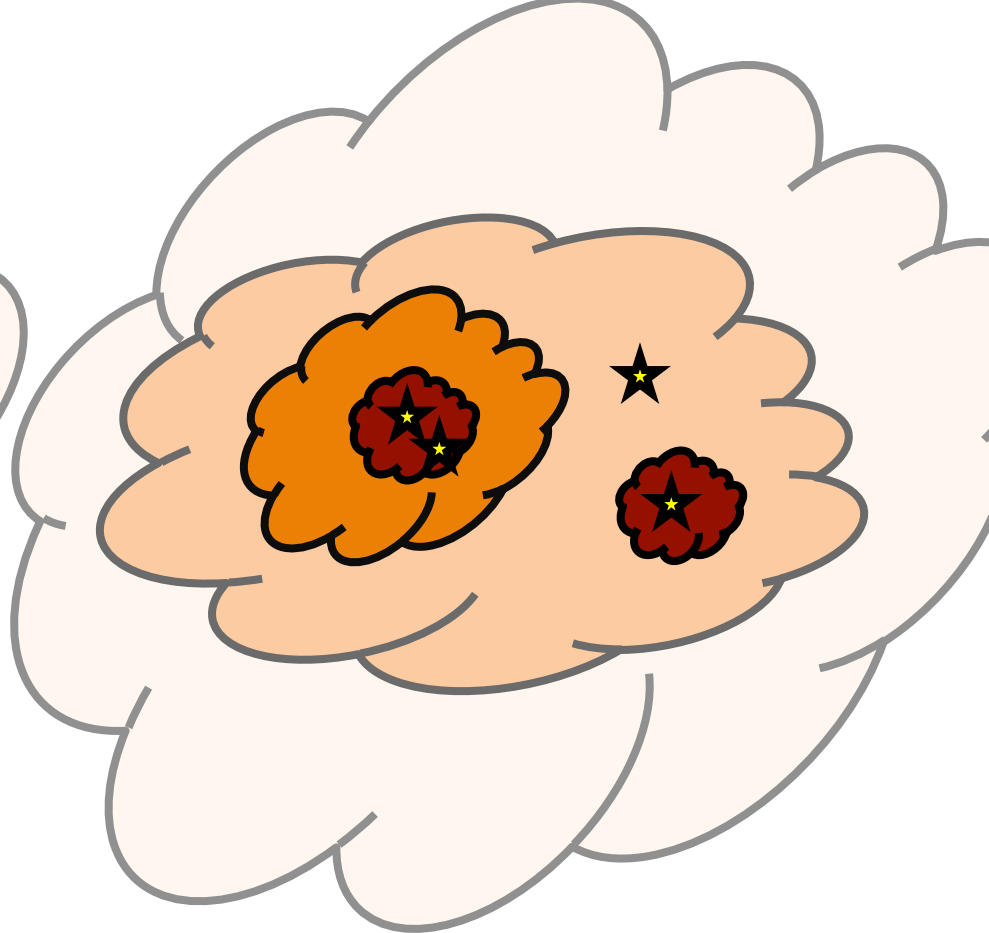
**INTERFEROMETER IMAGE**





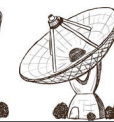
REAL SKY

$$\theta_{beam} = 1.22 \frac{\lambda}{B_{max}}$$



INTERFEROMETER IMAGE

$$LAS = 1.22 \frac{\lambda}{B_{min}}$$



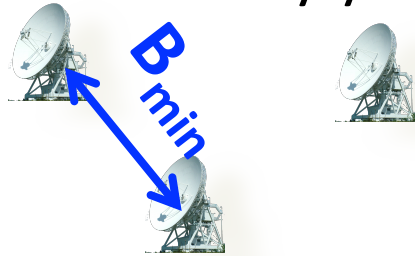
$B_{max}$

$B_{min}$

# Primary beam, synthesized beam, and LAS

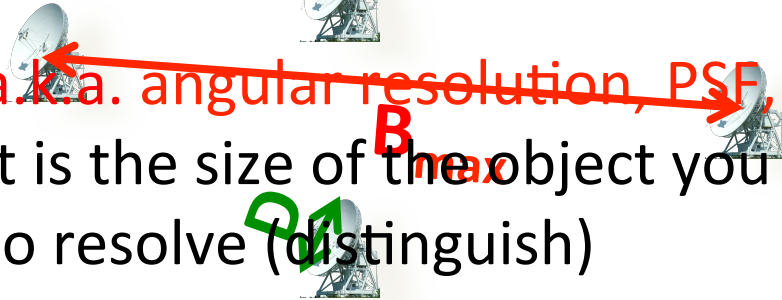
a.k.a. field of view (FOV), ...

the area of the sky you want to observe



a.k.a. angular resolution, PSF, ...

it is the size of the object you want to resolve (distinguish)



a.k.a. maximum angular size, ...

the largest size of your object  
how big it is?

## PRIMARY BEAM

$$PB = 1.22 \frac{\lambda}{D}$$

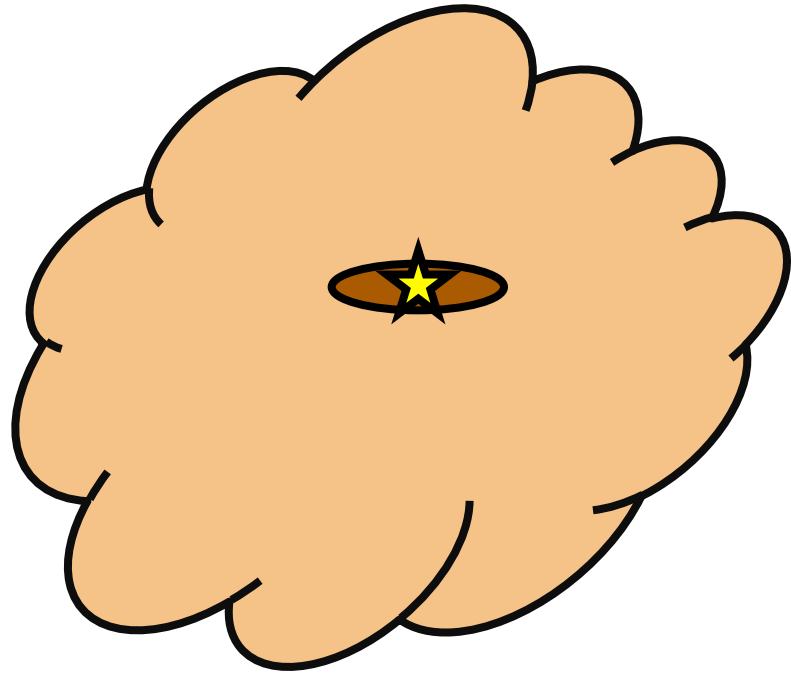
## SYNTHESIZED BEAM

$$\theta_{beam} = 1.22 \frac{\lambda}{B_{max}}$$

## LARGEST ANGULAR SCALE

$$LAS = 1.22 \frac{\lambda}{B_{min}}$$

# Example I: compact protoplanetary disk



**PRIMARY BEAM**

$$PB = 1.22 \frac{\lambda}{D}$$

**SYNTHESIZED BEAM**

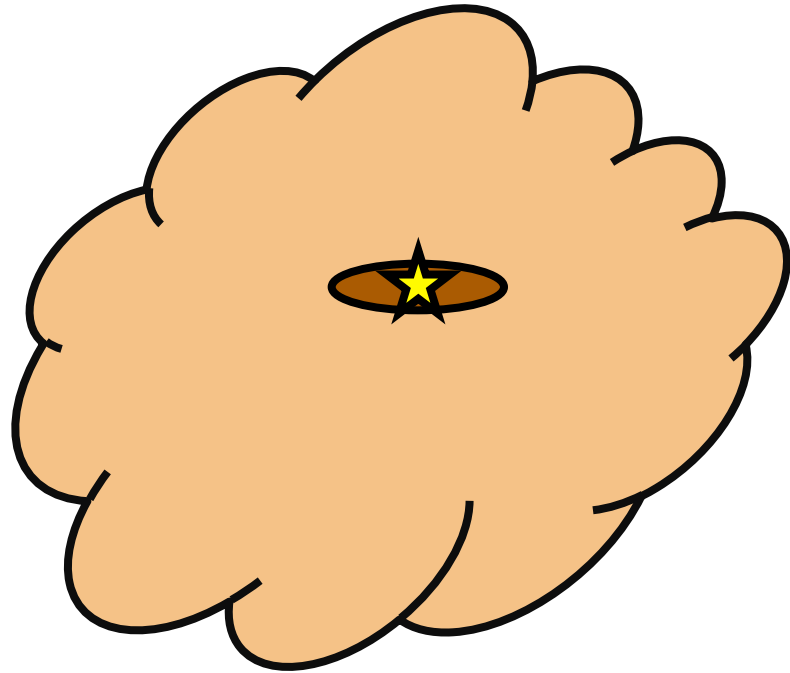
$$\theta_{beam} = 1.22 \frac{\lambda}{B_{max}}$$

**LARGEST ANGULAR SCALE**

$$LAS = 1.22 \frac{\lambda}{B_{min}}$$



# Example I: compact protoplanetary disk



## PRIMARY BEAM

$$PB = 1.22 \frac{\lambda}{D}$$

## SYNTHESIZED BEAM

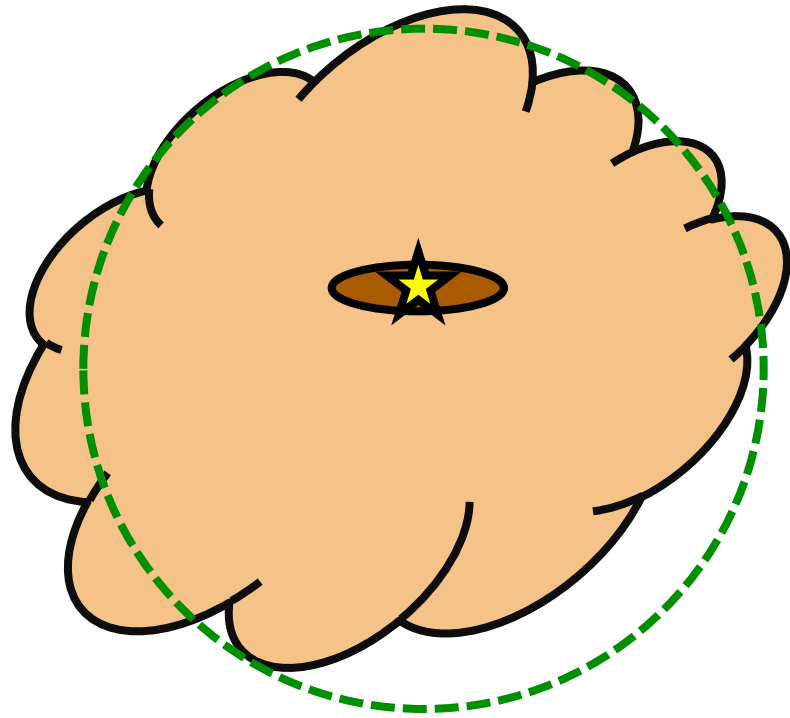
$$\theta_{beam} = 1.22 \frac{\lambda}{B_{max}}$$

## LARGEST ANGULAR SCALE

$$LAS = 1.22 \frac{\lambda}{B_{min}}$$

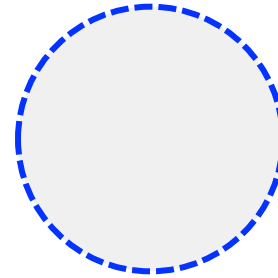


# Example I: compact protoplanetary disk



**PRIMARY BEAM**

$$PB = 1.22 \frac{\lambda}{D}$$



**SYNTHESIZED BEAM**

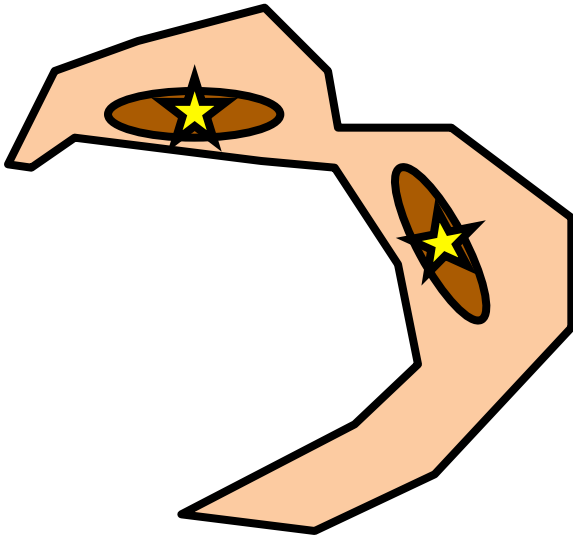
$$\theta_{beam} = 1.22 \frac{\lambda}{B_{max}}$$

**LARGEST ANGULAR SCALE**

$$LAS = 1.22 \frac{\lambda}{B_{min}}$$



# Example II: disks and filament



**PRIMARY BEAM**

$$PB = 1.22 \frac{\lambda}{D}$$

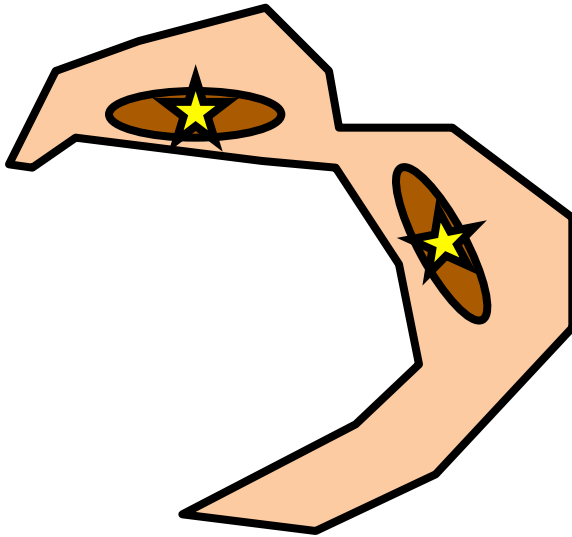
**SYNTHESIZED BEAM**

$$\theta_{beam} = 1.22 \frac{\lambda}{B_{max}}$$

**LARGEST ANGULAR SCALE**

$$LAS = 1.22 \frac{\lambda}{B_{min}}$$

# Example II: disks and filament



**PRIMARY BEAM**

$$PB = 1.22 \frac{\lambda}{D}$$

**SYNTHESIZED BEAM**

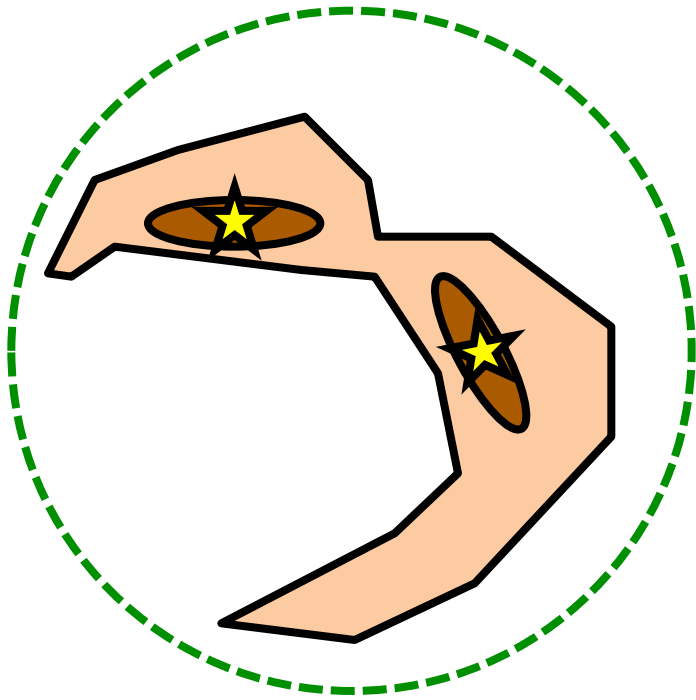
$$\theta_{beam} = 1.22 \frac{\lambda}{B_{max}}$$

**LARGEST ANGULAR SCALE**

$$LAS = 1.22 \frac{\lambda}{B_{min}}$$

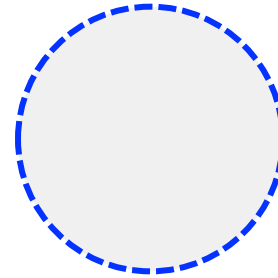


# Example II: disks and filament



**PRIMARY BEAM**

$$PB = 1.22 \frac{\lambda}{D}$$



**SYNTHESIZED BEAM**

$$\theta_{beam} = 1.22 \frac{\lambda}{B_{max}}$$

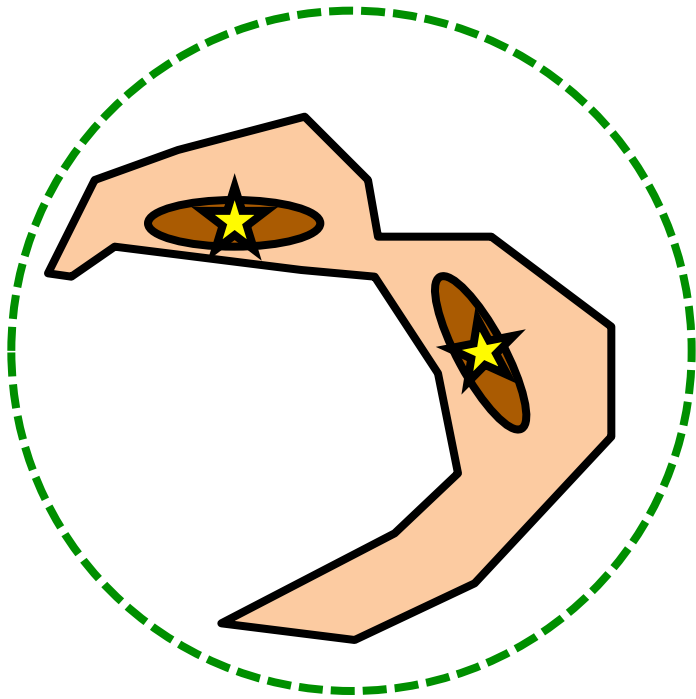
**LARGEST ANGULAR SCALE**

$$LAS = 1.22 \frac{\lambda}{B_{min}}$$



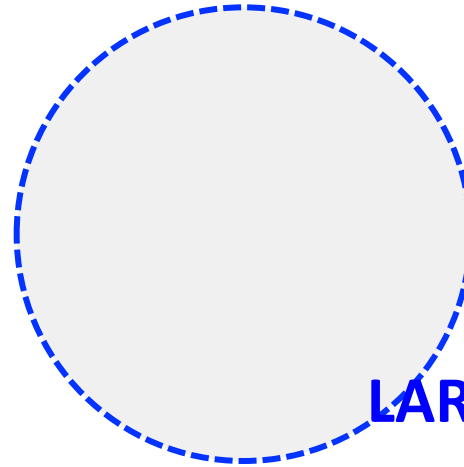


# Example II: disks and filament



**PRIMARY BEAM**

$$PB = 1.22 \frac{\lambda}{D}$$



**SYNTHESIZED BEAM**

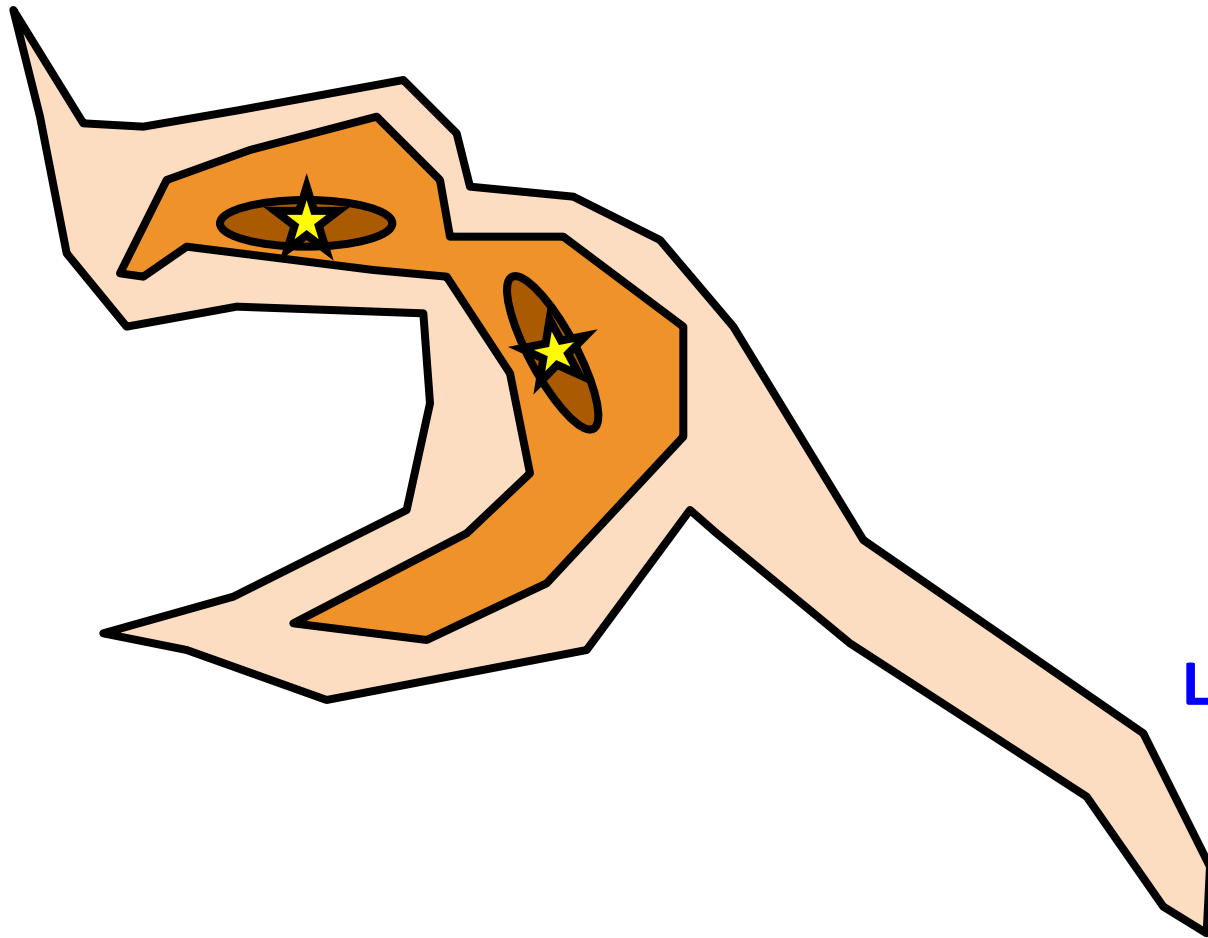
$$\theta_{beam} = 1.22 \frac{\lambda}{B_{max}}$$

**LARGEST ANGULAR SCALE**

$$LAS = 1.22 \frac{\lambda}{B_{min}}$$



# Example III: disks and extended filament



**PRIMARY BEAM**

$$PB = 1.22 \frac{\lambda}{D}$$

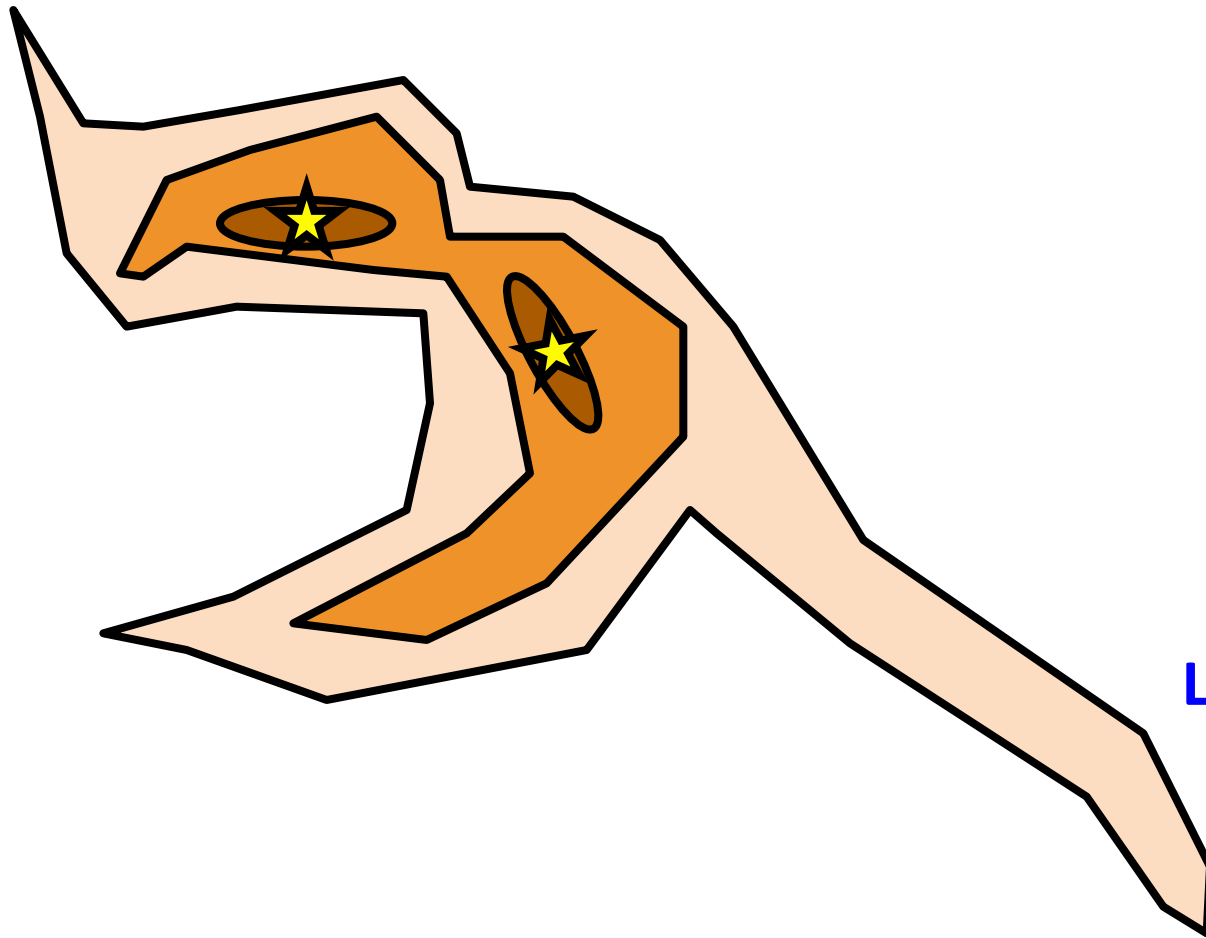
**SYNTHESIZED BEAM**

$$\theta_{beam} = 1.22 \frac{\lambda}{B_{max}}$$

**LARGEST ANGULAR SCALE**

$$LAS = 1.22 \frac{\lambda}{B_{min}}$$

# Example III: disks and extended filament



**PRIMARY BEAM**

$$PB = 1.22 \frac{\lambda}{D}$$

**SYNTHESIZED BEAM**

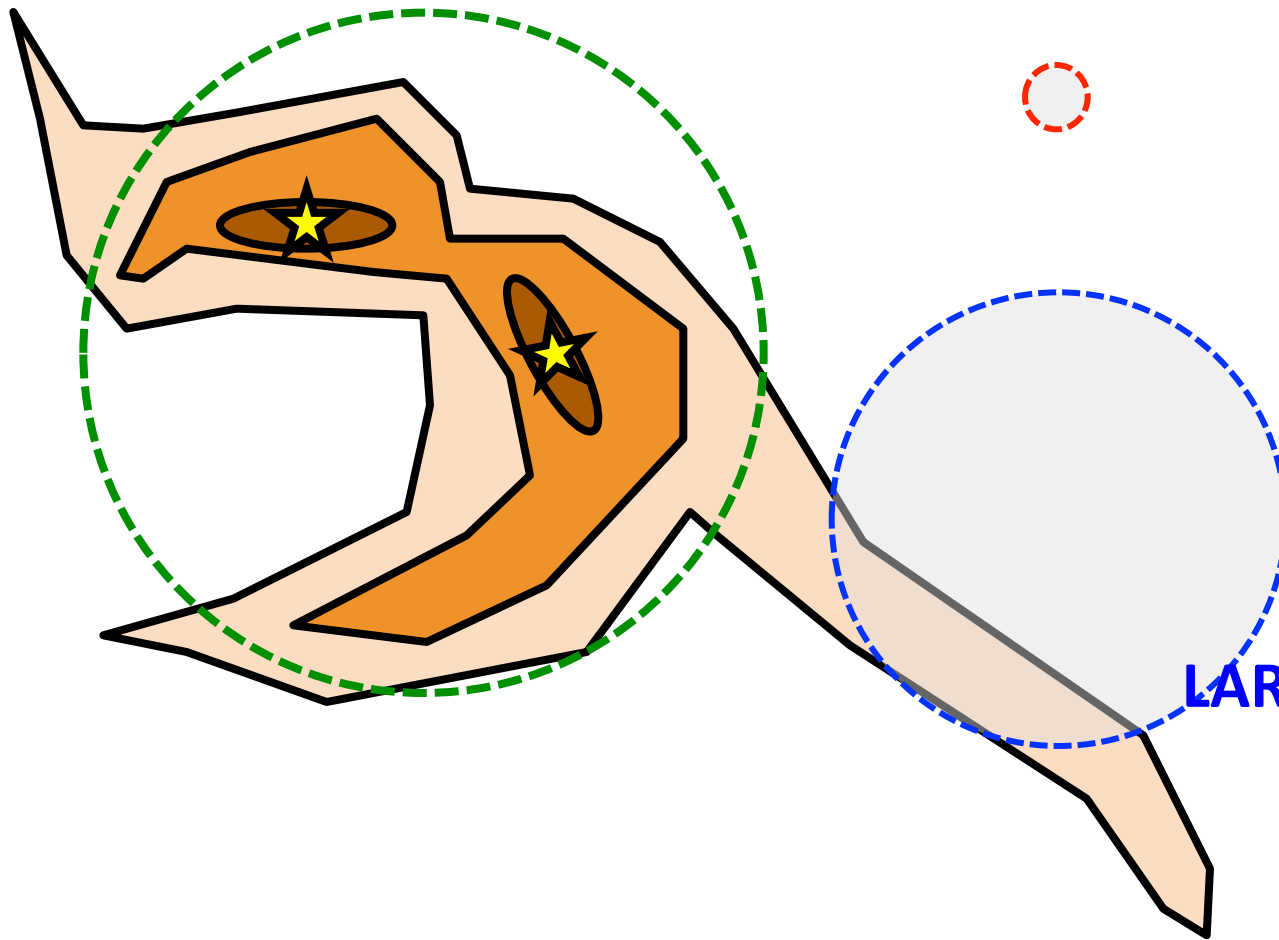
$$\theta_{beam} = 1.22 \frac{\lambda}{B_{max}}$$

**LARGEST ANGULAR SCALE**

$$LAS = 1.22 \frac{\lambda}{B_{min}}$$



# Example III: disks and extended filament



**PRIMARY BEAM**

$$PB = 1.22 \frac{\lambda}{D}$$

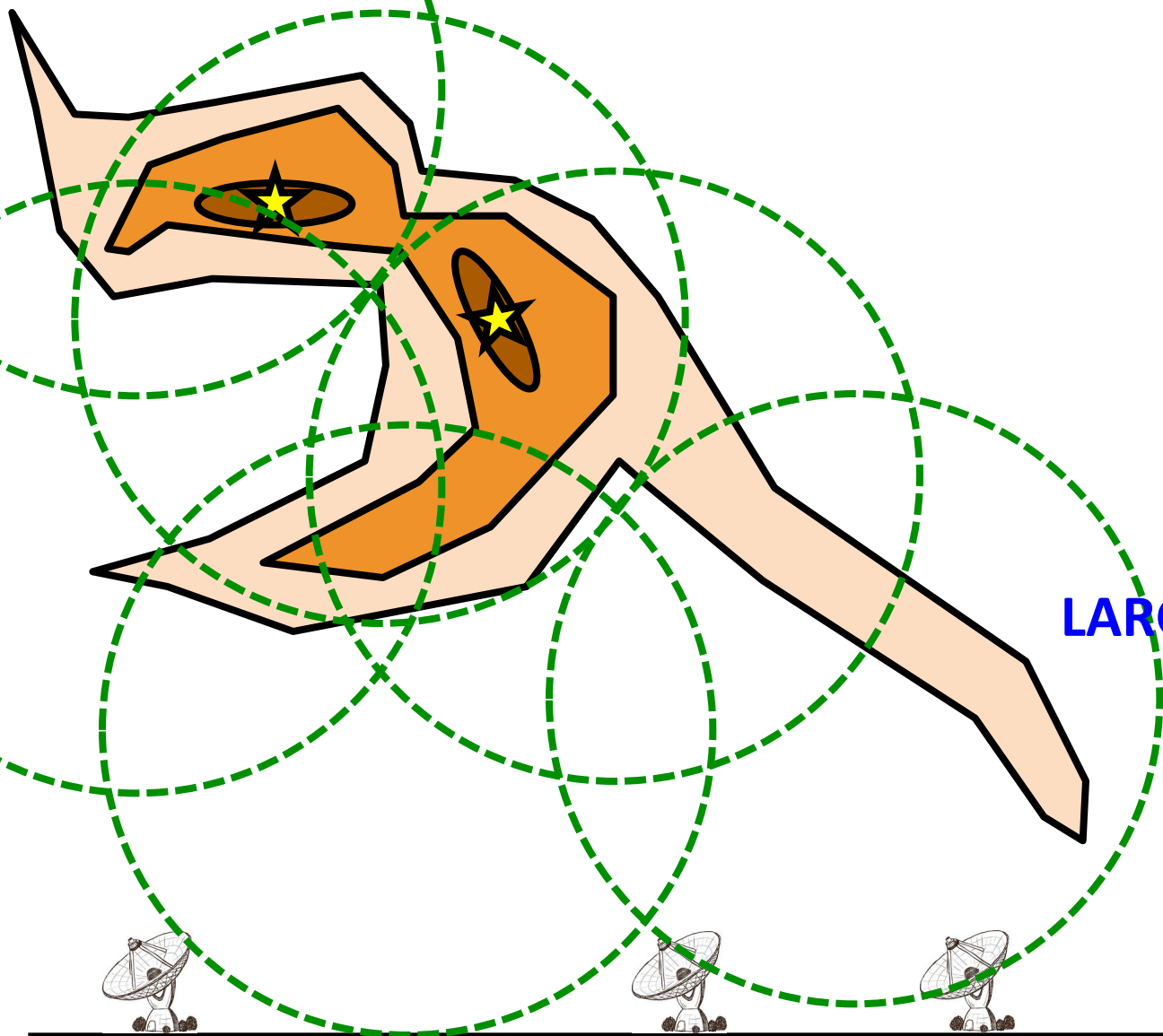
**SYNTHESIZED BEAM**

$$\theta_{beam} = 1.22 \frac{\lambda}{B_{max}}$$

**LARGEST ANGULAR SCALE**

$$LAS = 1.22 \frac{\lambda}{B_{min}}$$

# Example III: disks and extended filament



**PRIMARY BEAM**

$$PB = 1.22 \frac{\lambda}{D}$$

**SYNTHESIZED BEAM**

$$\theta_{beam} = 1.22 \frac{\lambda}{B_{max}}$$

**LARGEST ANGULAR SCALE**

$$LAS = 1.22 \frac{\lambda}{B_{min}}$$

# Outline

## Part 1

- Introduction to aperture synthesis
- Interferometers: spatial filters

## Part 2

- An overview to the correlator and spectral receivers
- Interferometers: spectral setup





# Part 2: spectral setup, receivers and correlator



German ARC node

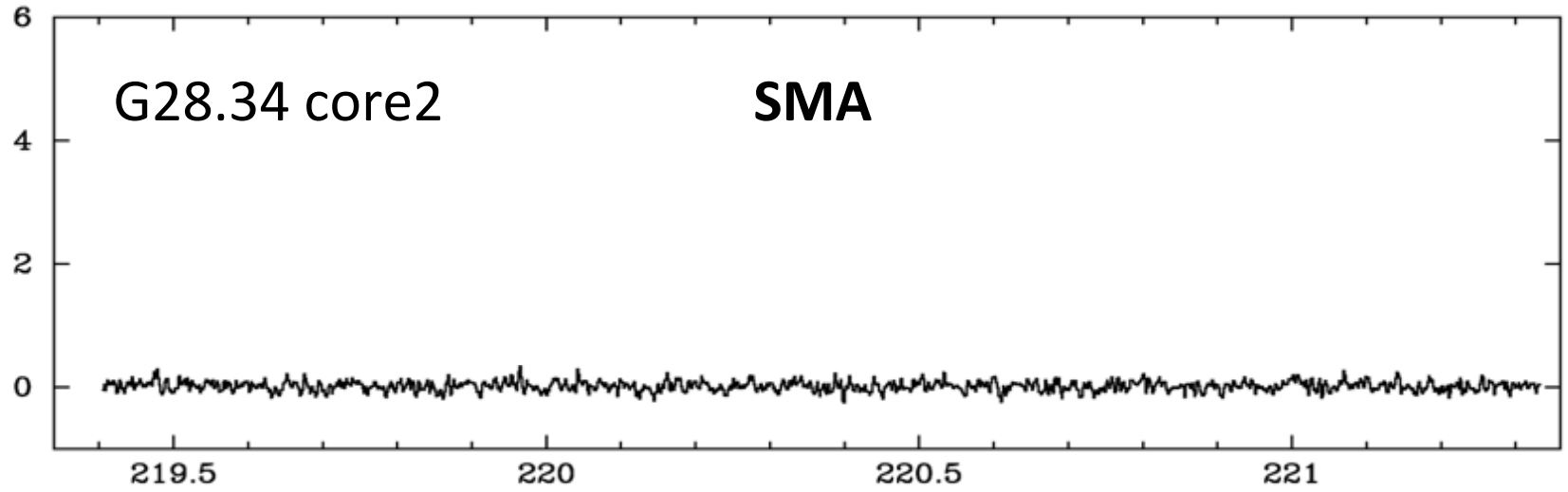
# Key concepts to learn

## Part 2

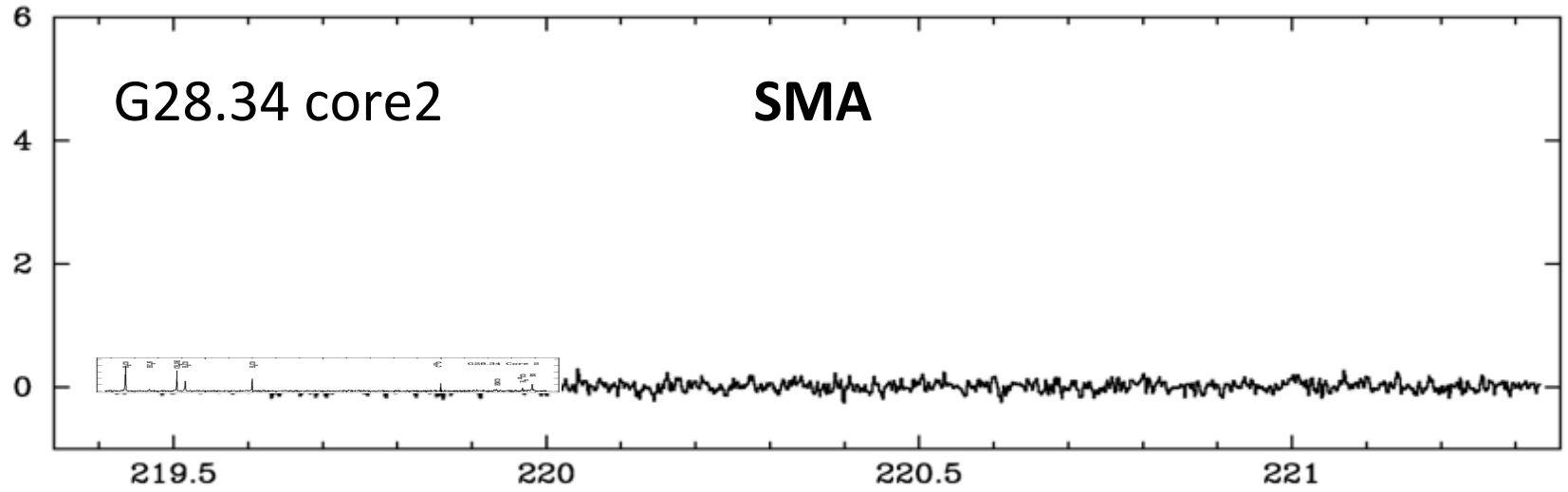
- Spectral lines
- Rest frequency
- Source velocity and redshift
- Line width
- Spectral resolution



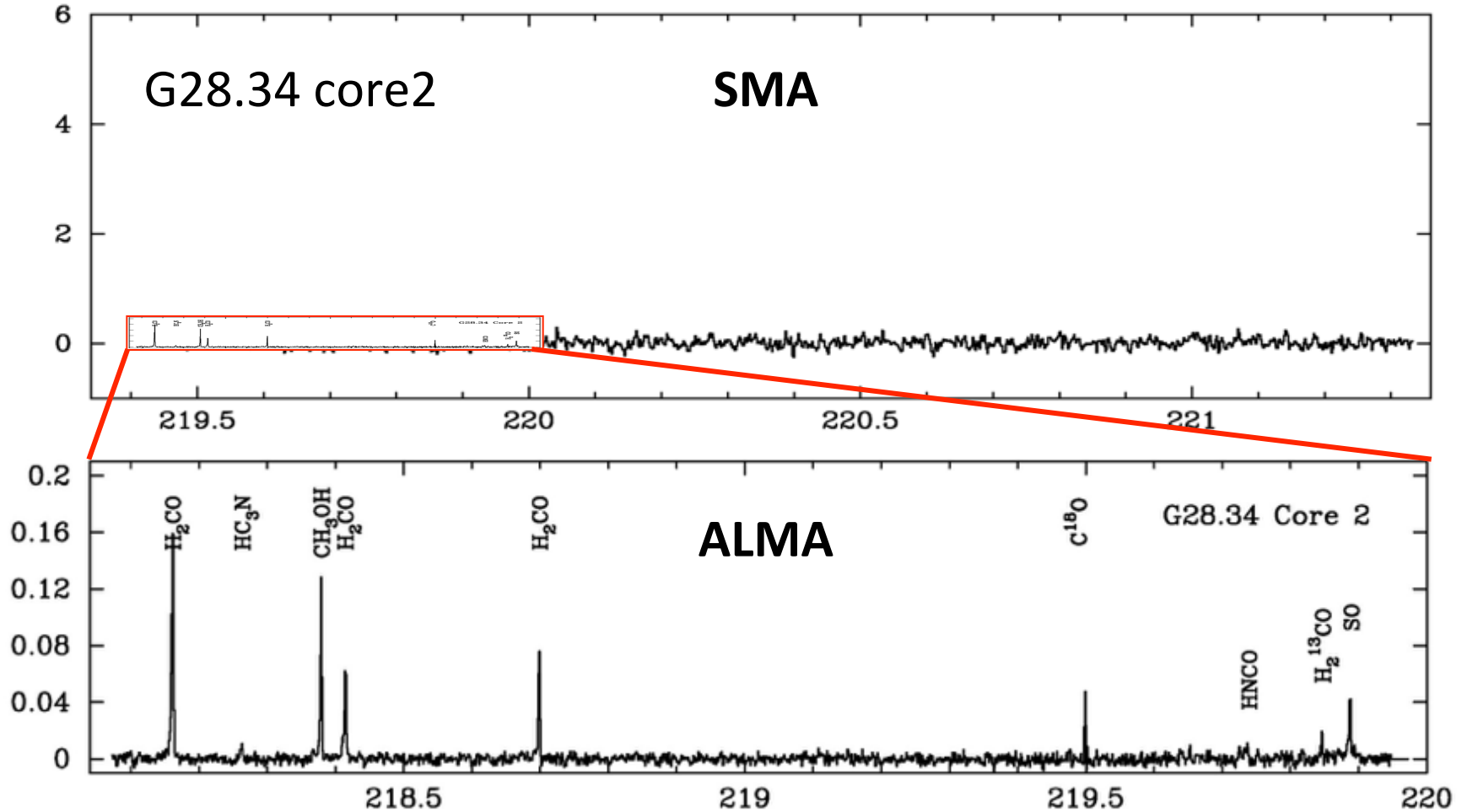
# Can we detect spectral lines?



# Can we detect spectral lines?



# Can we detect spectral lines?

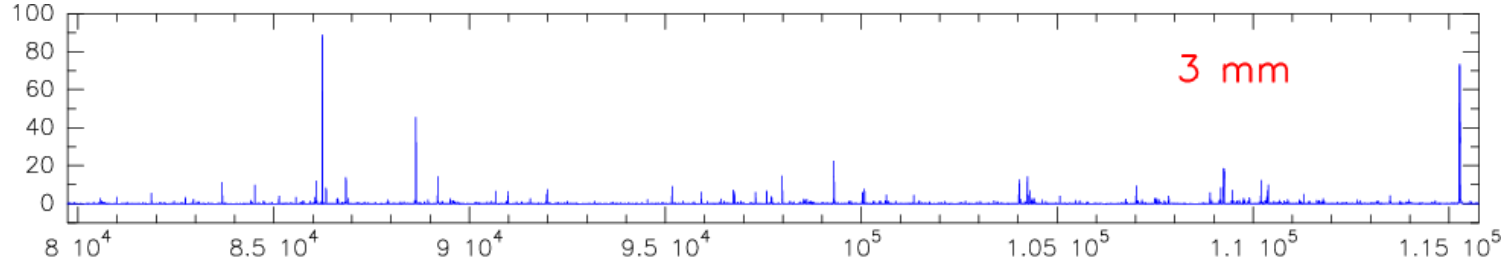


Zhang et al (2008)

Zhang et al (2014)

# Can we detect spectral lines?

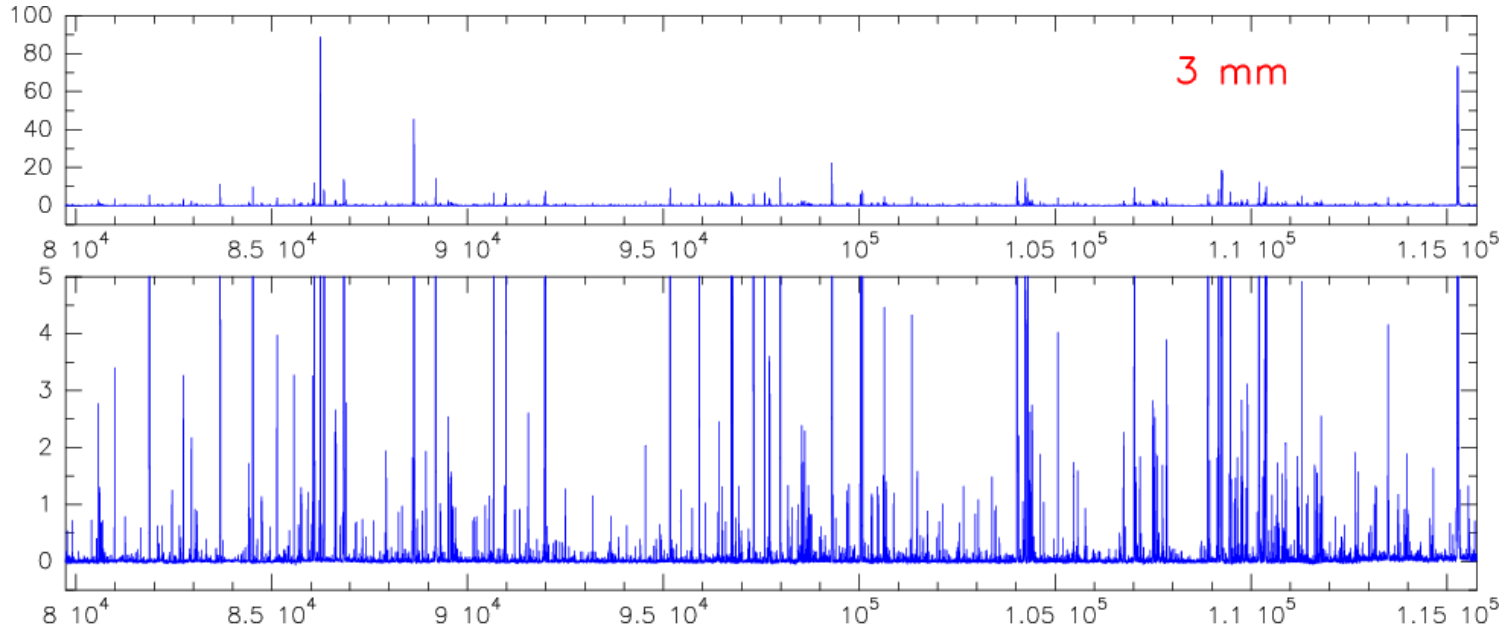
When sensitivity can be a problem  
... entering the ALMA era





# Can we detect spectral lines?

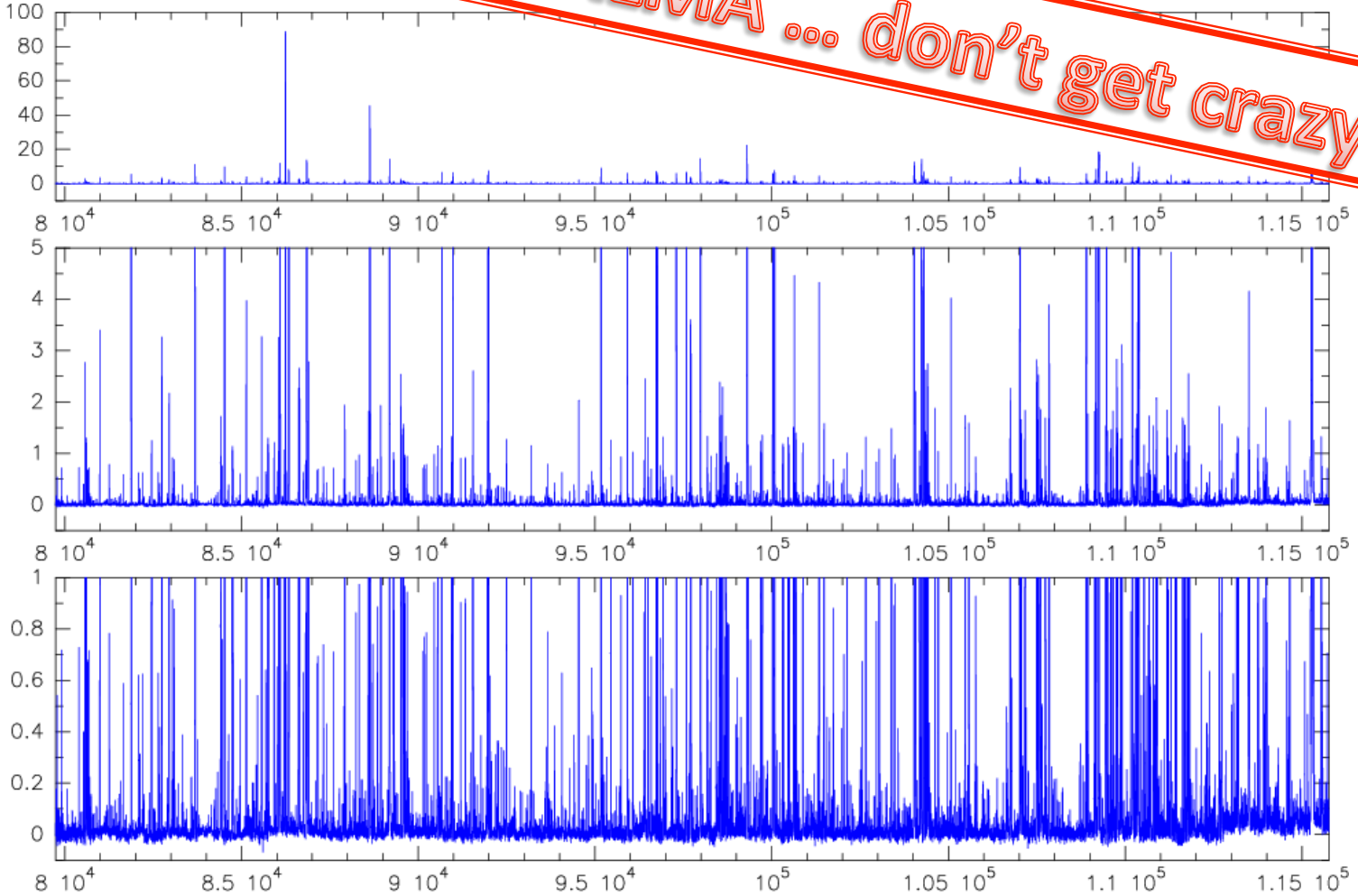
When sensitivity can be a problem  
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# Can we detect spectral lines?

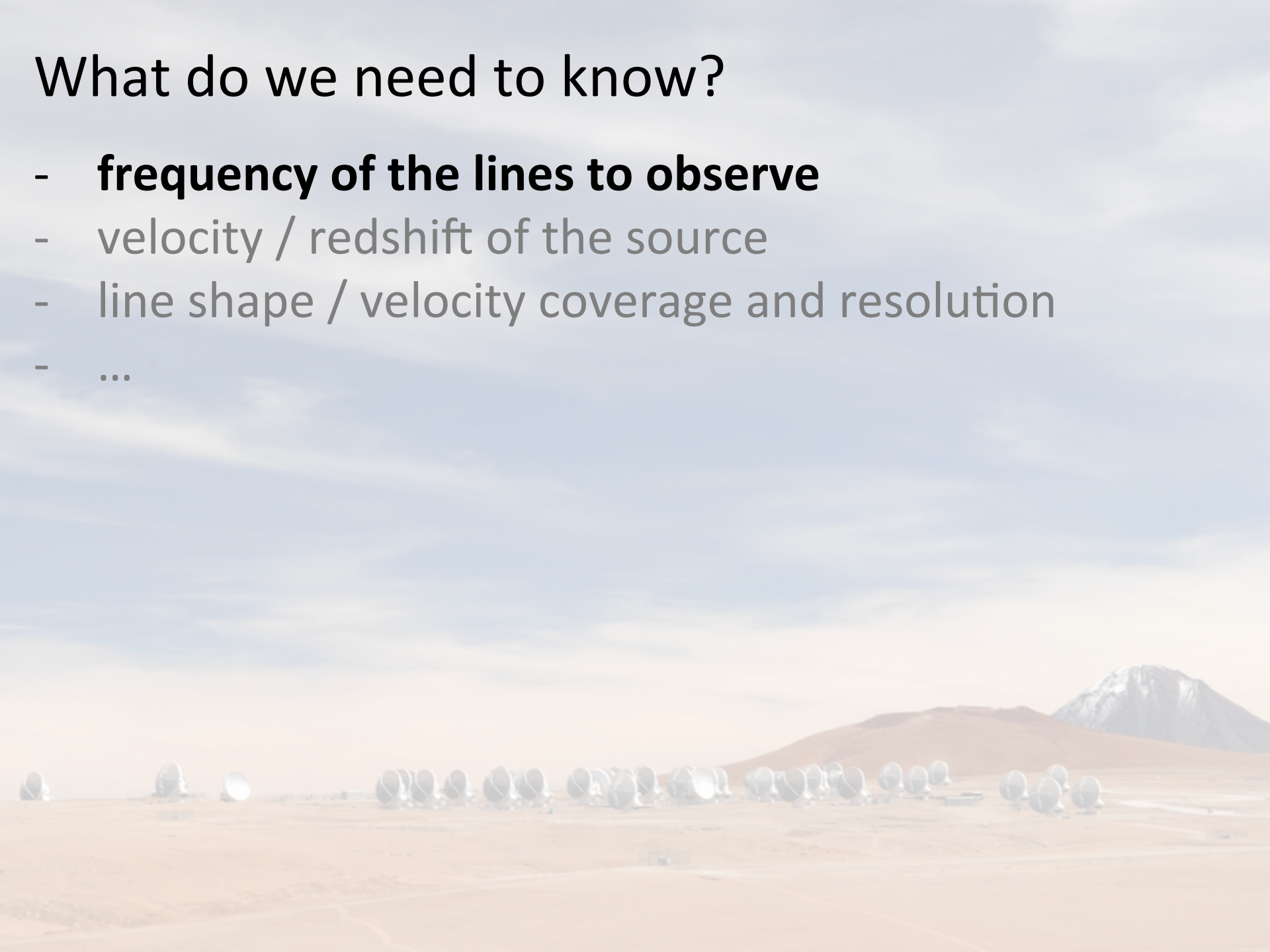
*With ALMA ... don't get crazy!*

When sensitivity can be a problem  
... entering the ALMA era



# What do we need to know?

- **frequency of the lines to observe**
- velocity / redshift of the source
- line shape / velocity coverage and resolution
- ...



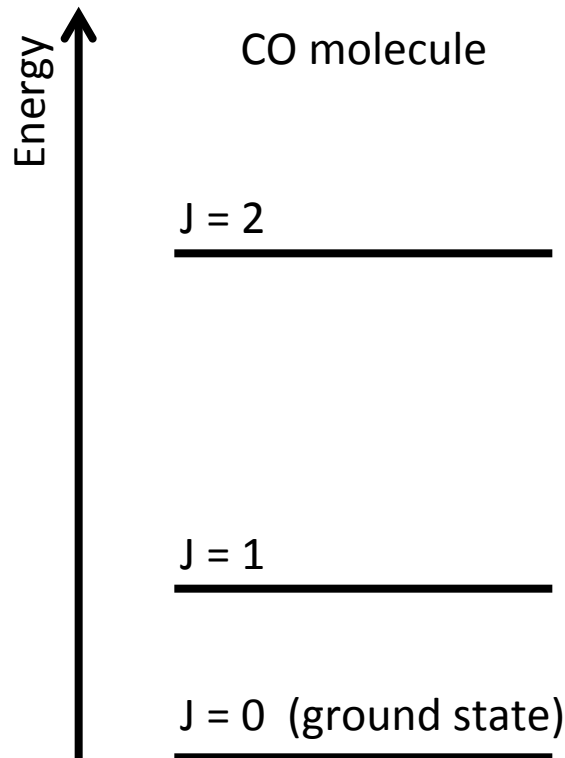
# Basic concepts of spectral line observations

Rest frequency

# Basic concepts of spectral line observations

## Rest frequency

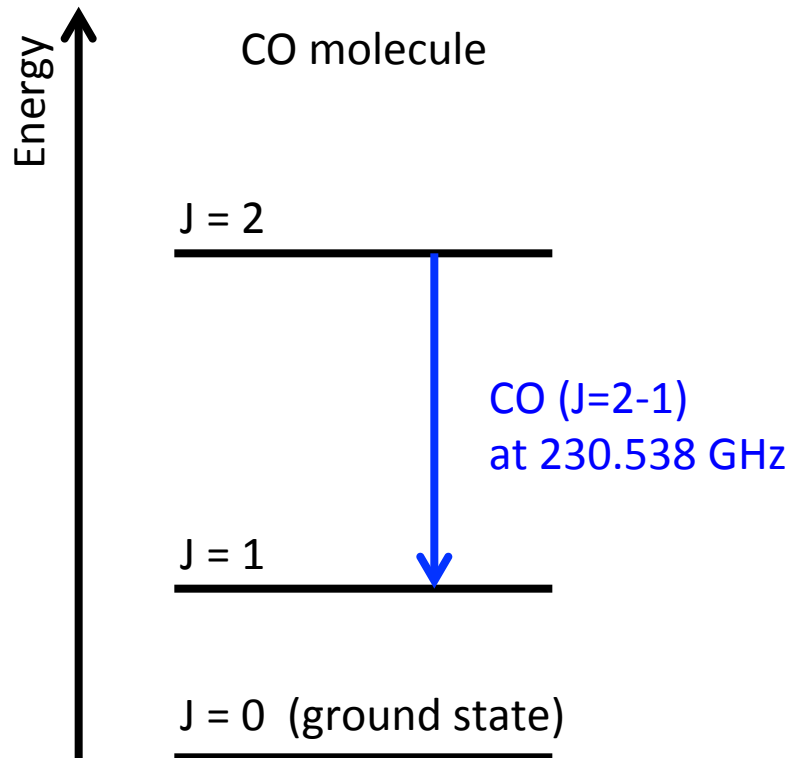
spectral line: transition between two different energy levels of a molecule, atom or ion



# Basic concepts of spectral line observations

## Rest frequency

spectral line: transition between two different energy levels of a molecule, atom or ion

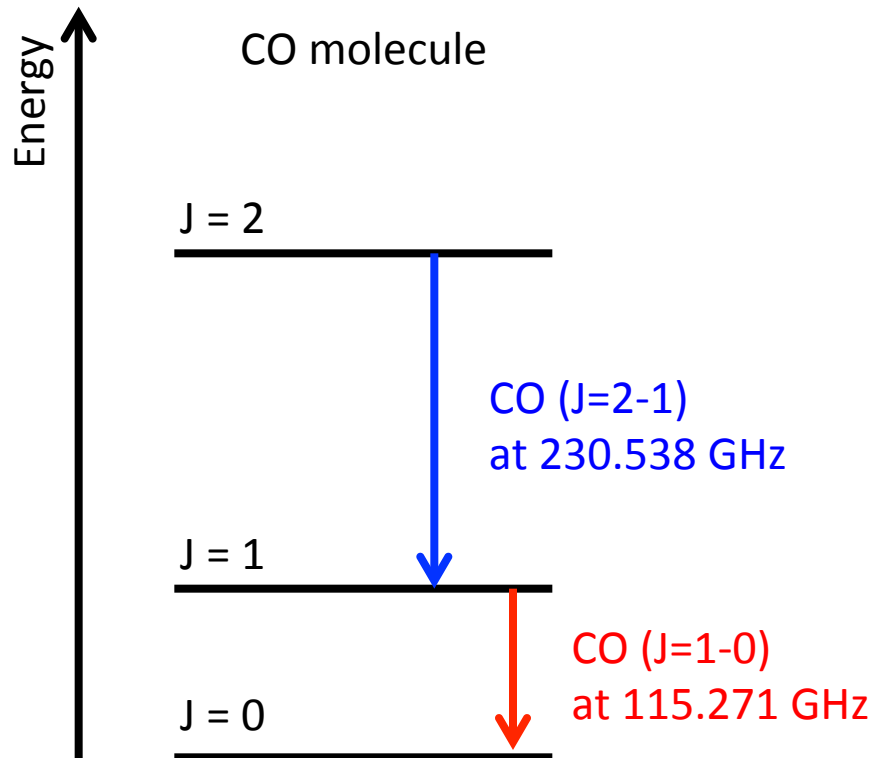




# Basic concepts of spectral line observations

## Rest frequency

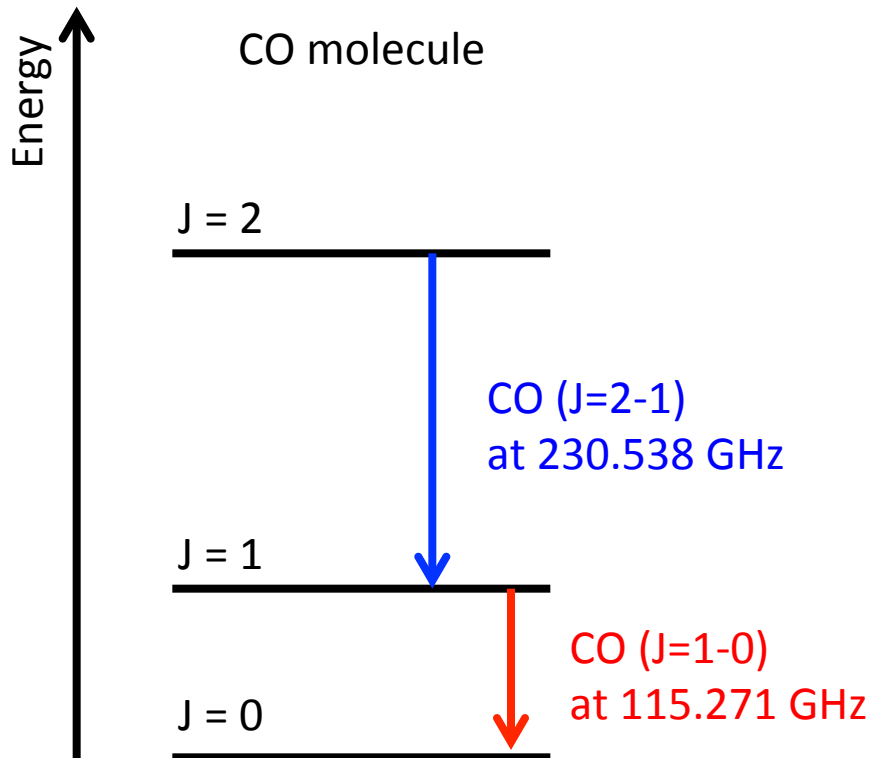
spectral line: transition between two different energy levels of a molecule, atom or ion



# Basic concepts of spectral line observations

## Rest frequency

spectral line: transition between two different energy levels of a molecule, atom or ion



**Rest frequencies** can be found in molecular databases:

CDMS

[www.astro.uni-koeln.de/cdms](http://www.astro.uni-koeln.de/cdms)

JPL

[spec.jpl.nasa.gov](http://spec.jpl.nasa.gov)

Splatalogue

[www.splatalogue.net](http://www.splatalogue.net)

# What do we need to know?

- frequency of the lines to observe
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# Basic concepts of spectral line observations

Velocity ( $V_{lsr}$ ) / redshift ( $z$ )

# Basic concepts of spectral line observations

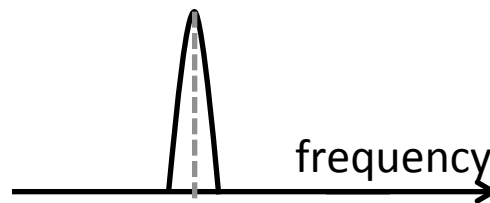
Velocity ( $V_{lsr}$ ) / redshift ( $z$ )

... from rest to sky frequencies (“**doppler effect**”)

# Basic concepts of spectral line observations

Velocity ( $V_{lsr}$ ) / redshift ( $z$ )

... from rest to sky frequencies ("**doppler effect**")



230.538 GHz  
Band 6



source  
with  $v = 0$

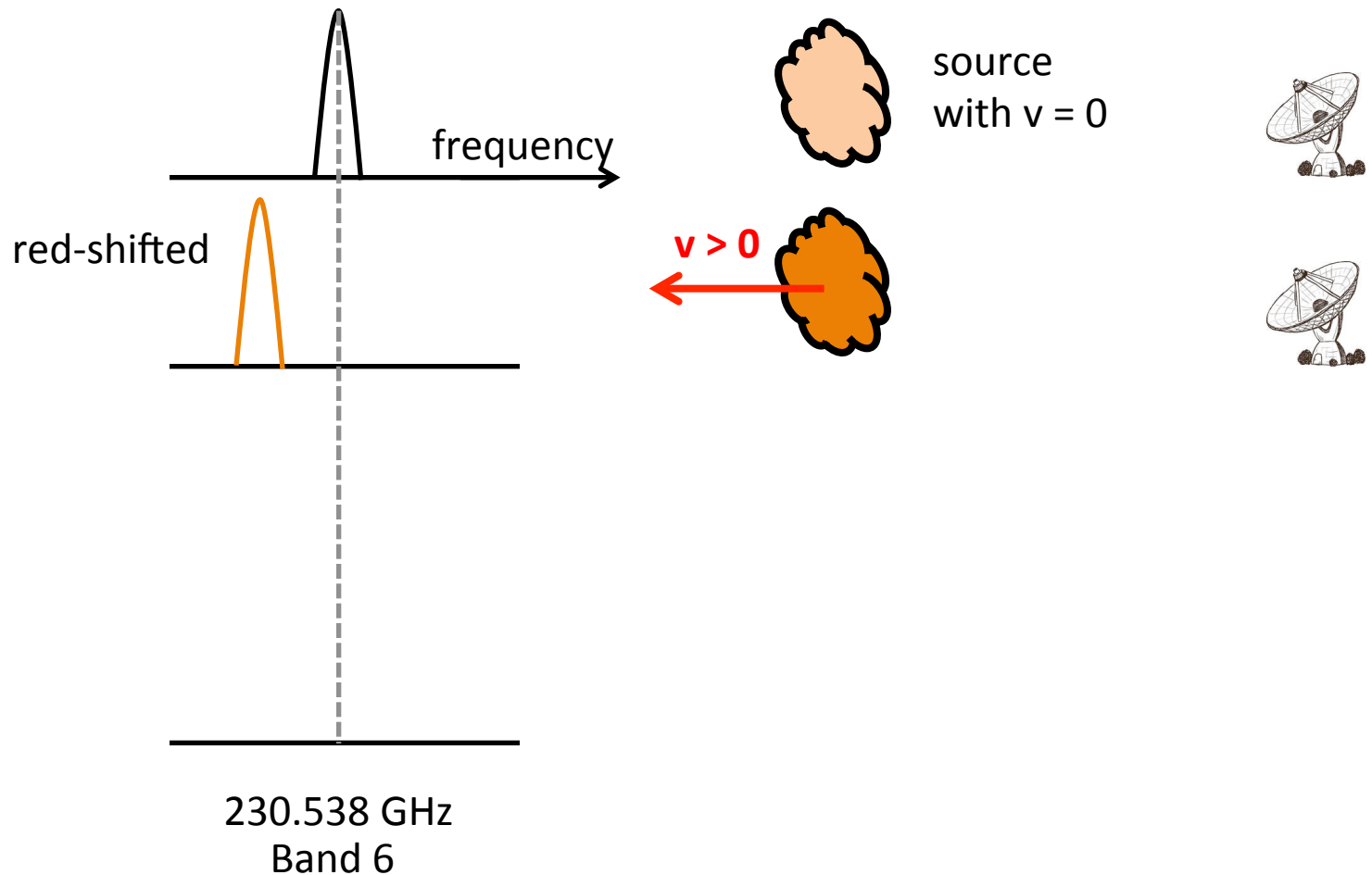




# Basic concepts of spectral line observations

Velocity ( $V_{lsr}$ ) / redshift ( $z$ )

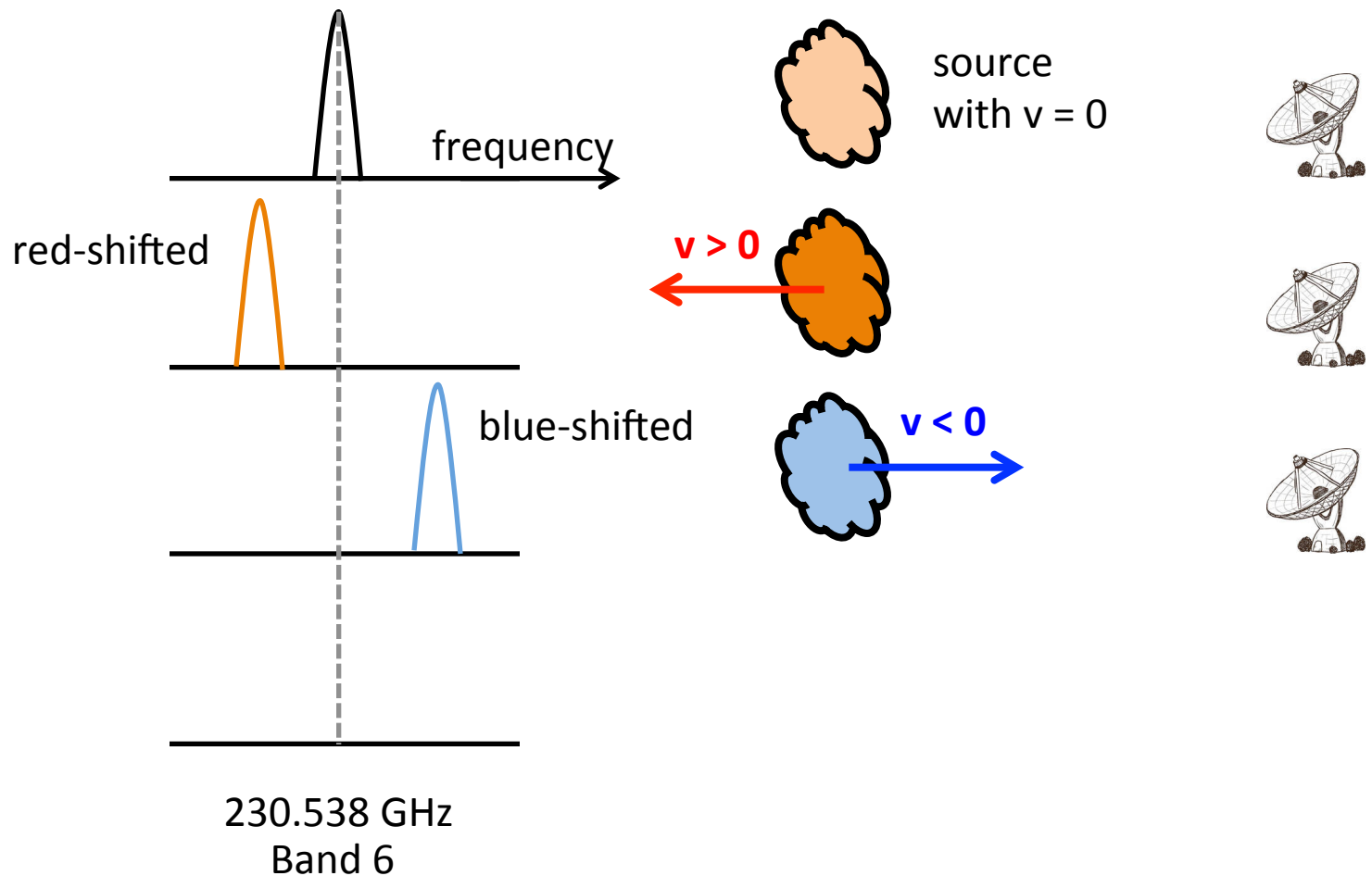
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# Basic concepts of spectral line observations

Velocity ( $V_{lsr}$ ) / redshift ( $z$ )

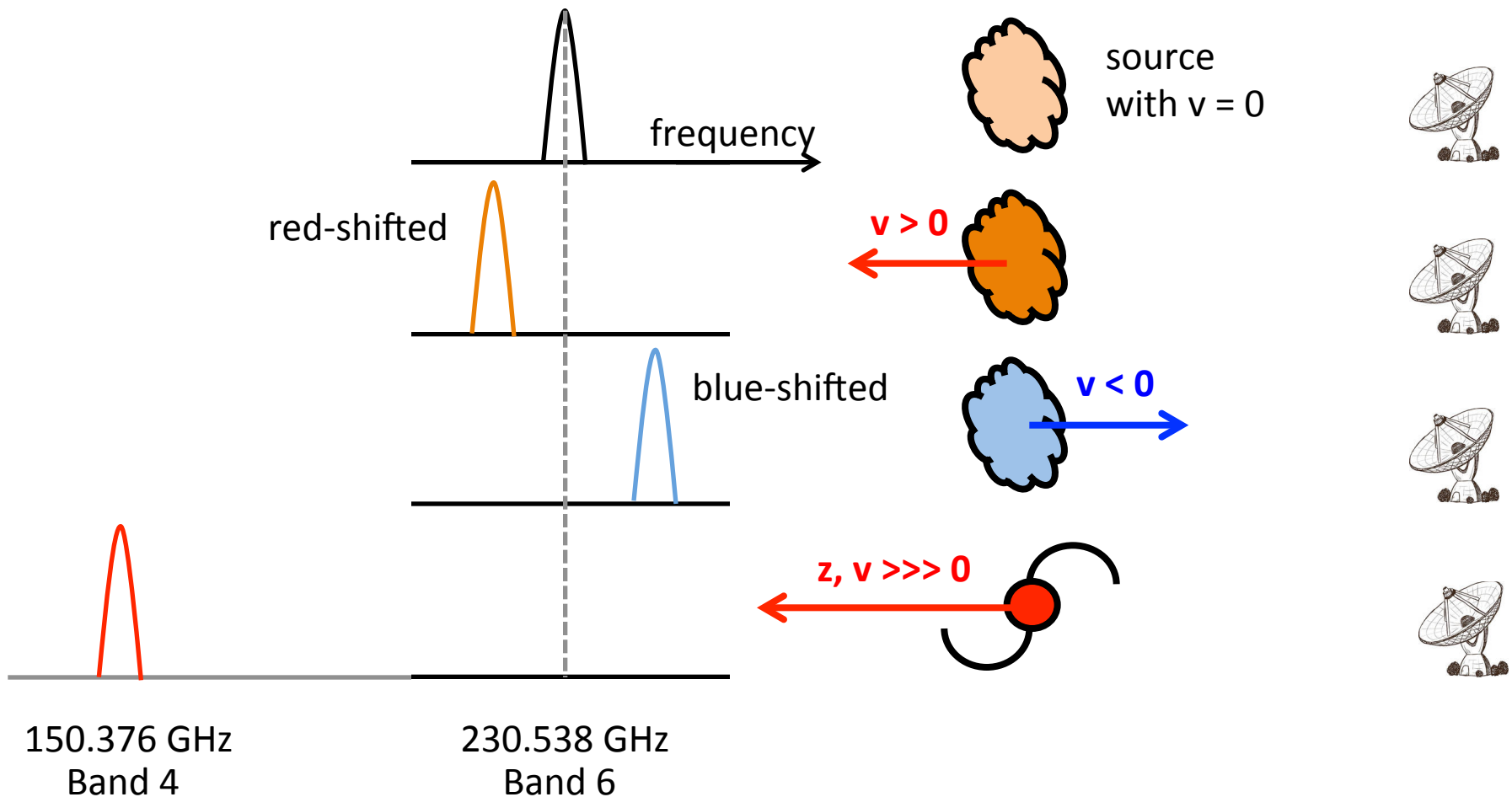
... from rest to sky frequencies (“**doppler effect**”)



# Basic concepts of spectral line observations

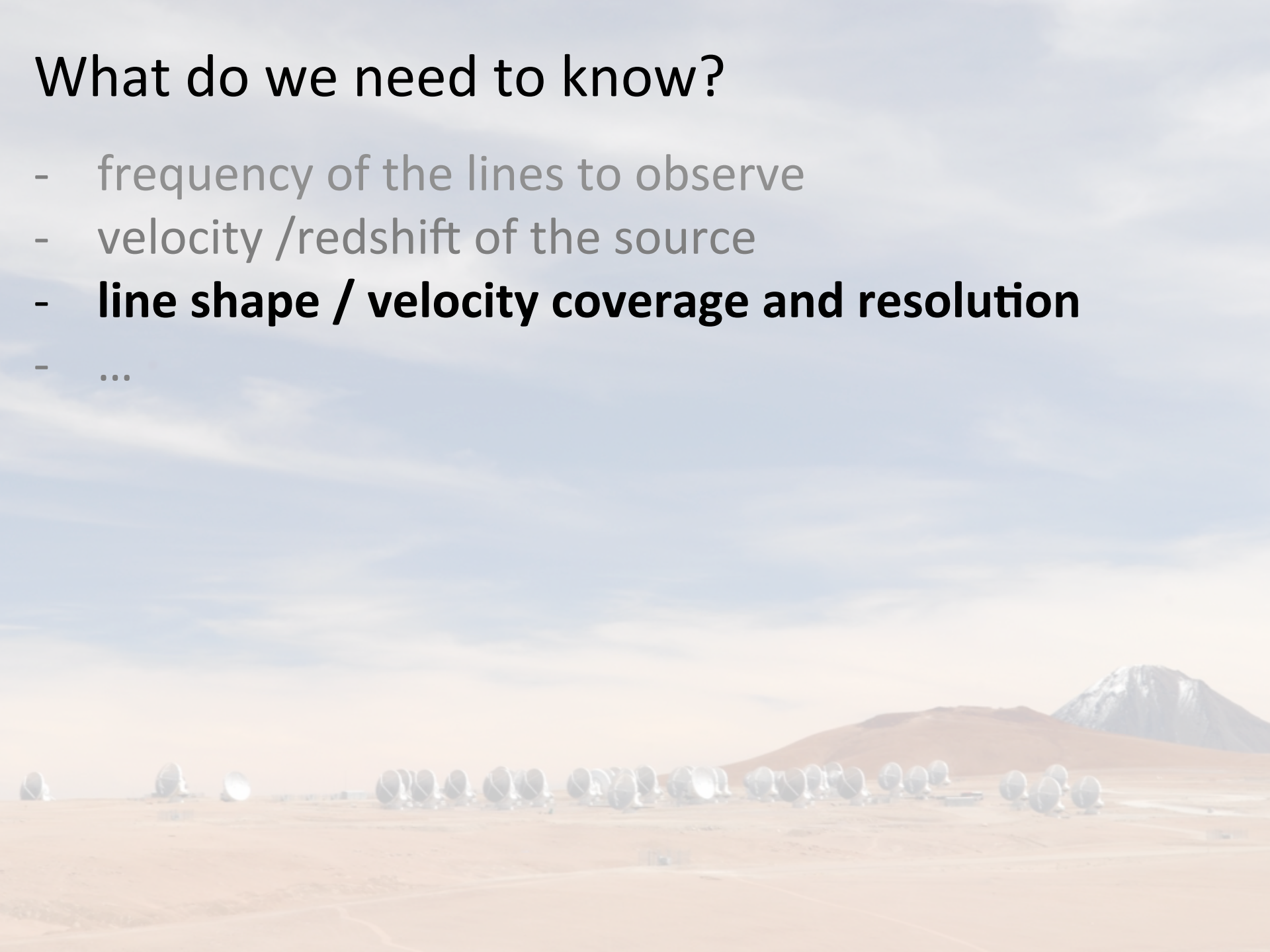
Velocity ( $V_{lsr}$ ) / redshift ( $z$ )

... from rest to sky frequencies (“**doppler effect**”)



# What do we need to know?

- frequency of the lines to observe
- velocity /redshift of the source
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# Basic concepts of spectral line observations

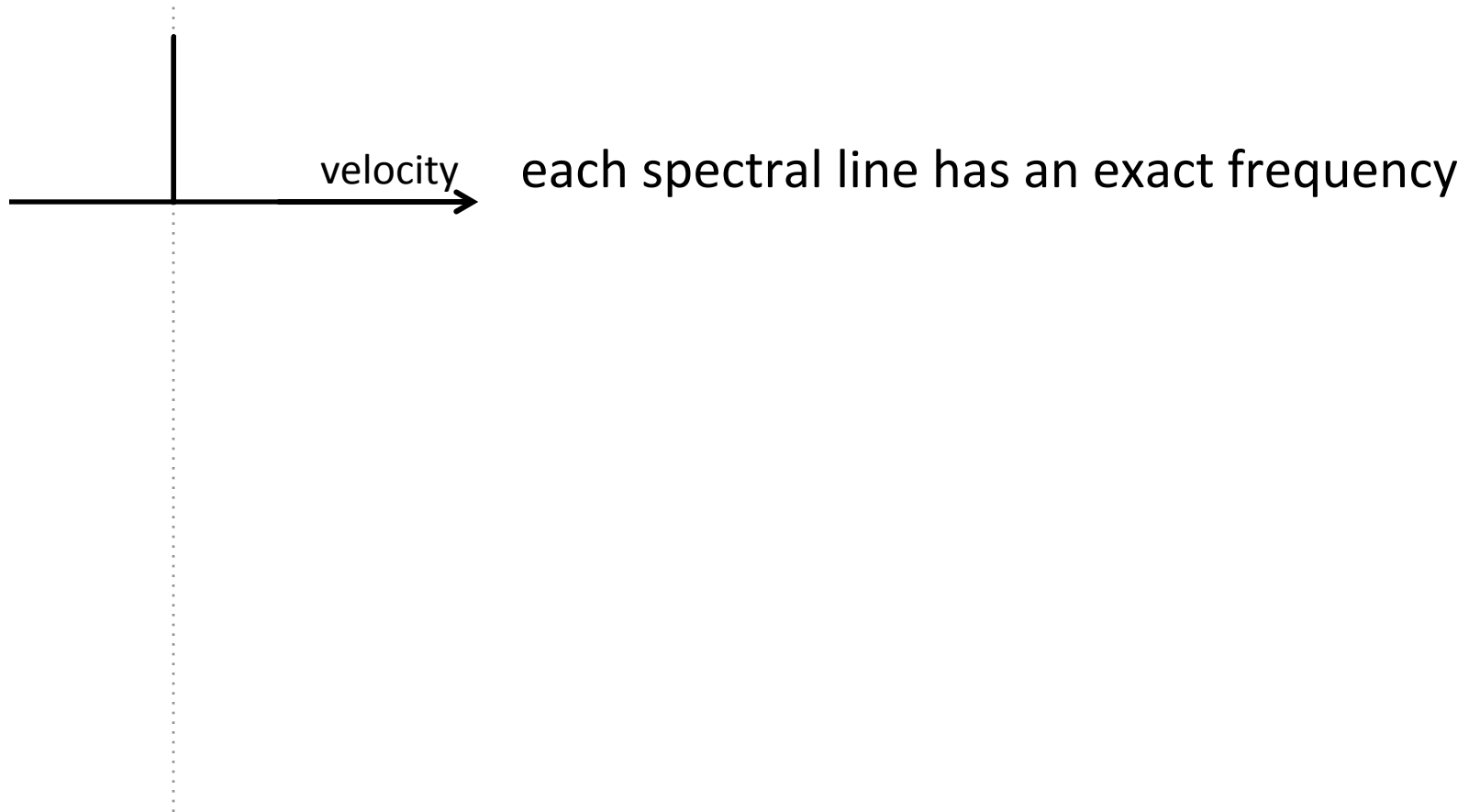
## Linewidth ( $\Delta\nu$ )

the spectral line will have a width that depends on the properties of the object you are studying

# Basic concepts of spectral line observations

## Linewidth ( $\Delta v$ )

the spectral line will have a width that depends on the properties of the object you are studying

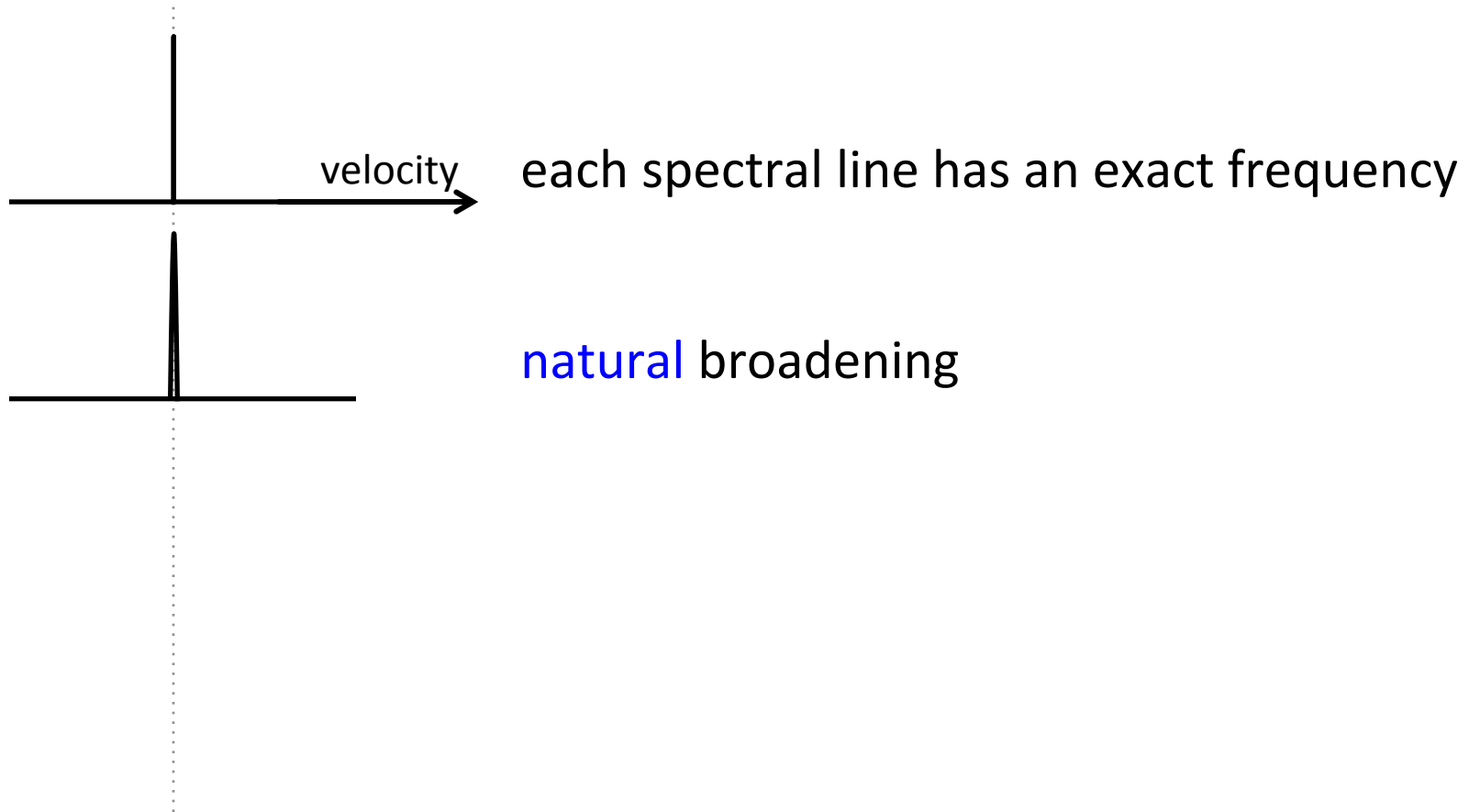




# Basic concepts of spectral line observations

## Linewidth ( $\Delta v$ )

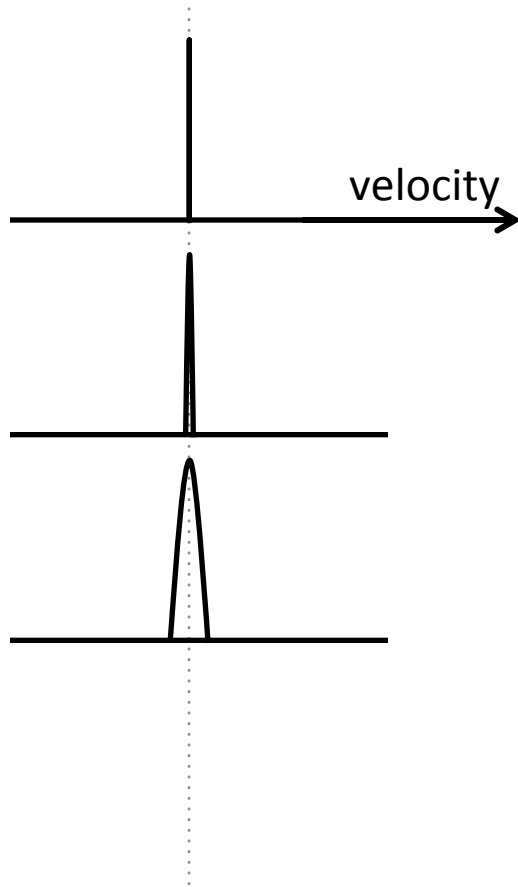
the spectral line will have a width that depends on the properties of the object you are studying



# Basic concepts of spectral line observations

## Linewidth ( $\Delta v$ )

the spectral line will have a width that depends on the properties of the object you are studying



each spectral line has an exact frequency

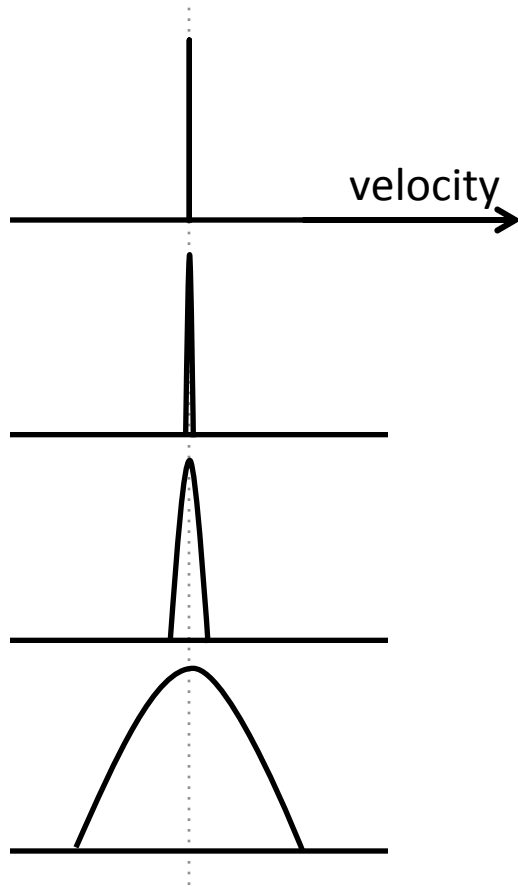
natural broadening

thermal, microturbulent, pressure broadening

# Basic concepts of spectral line observations

## Linewidth ( $\Delta v$ )

the spectral line will have a width that depends on the properties of the object you are studying



each spectral line has an exact frequency

natural broadening

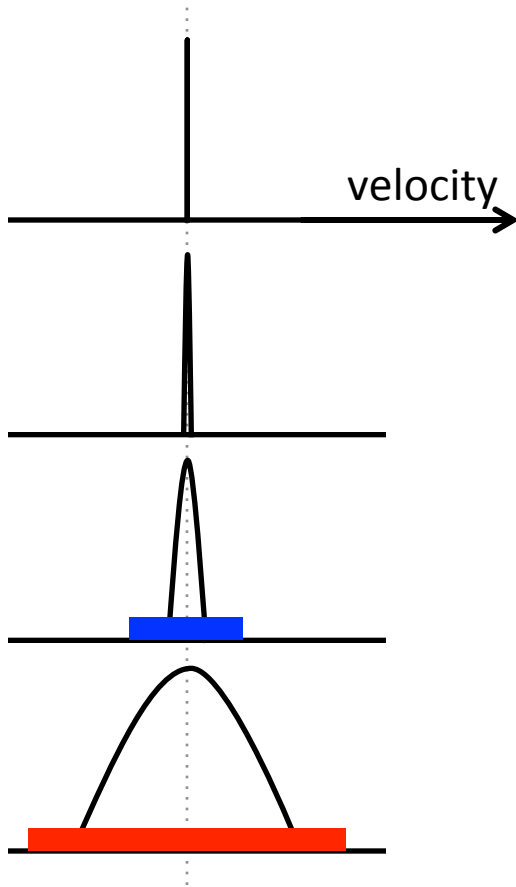
thermal, microturbulent, pressure broadening

large-scale motions broadening

# Basic concepts of spectral line observations

## Linewidth ( $\Delta v$ )

the spectral line will have a width that depends on the properties of the object you are studying

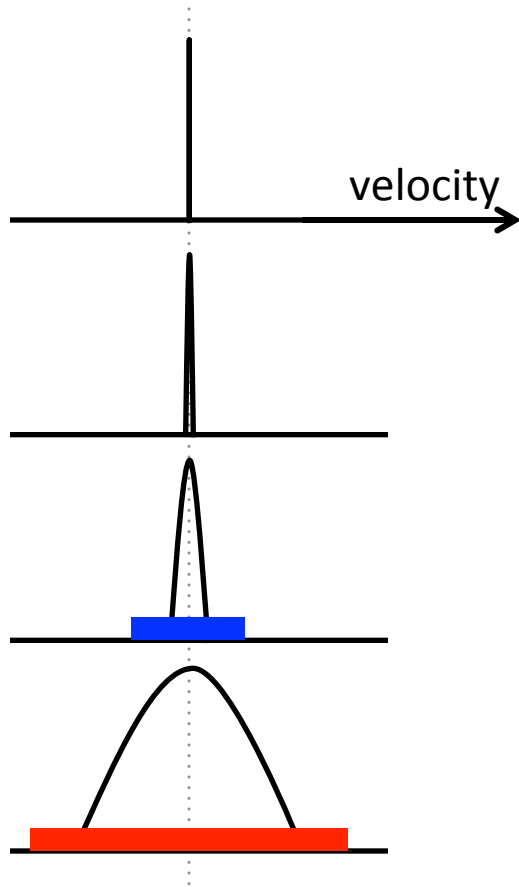


Depending on the linewidth of the line, you will cover a **narrower/broader** frequency (velocity) range

# Basic concepts of spectral line observations

## Linewidth ( $\Delta v$ )

the spectral line will have a width that depends on the properties of the object you are studying



velocity  
linewidth  
(km/s)

frequency  
linewidth  
(Hz)

$$\Delta V = -\Delta \nu \frac{c}{\nu_0}$$

Depending on the linewidth of the line,  
you will cover a **narrower/broader**  
**frequency (velocity) range**

# What do we need to know?

- frequency of the lines to observe
- velocity / redshift of the source
- line shape / velocity coverage and resolution
- ...



# What do we need to know?

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## Spectral observations in a radio-interferometer

- frequency bands
- receivers
- correlator





# What do we need to know?

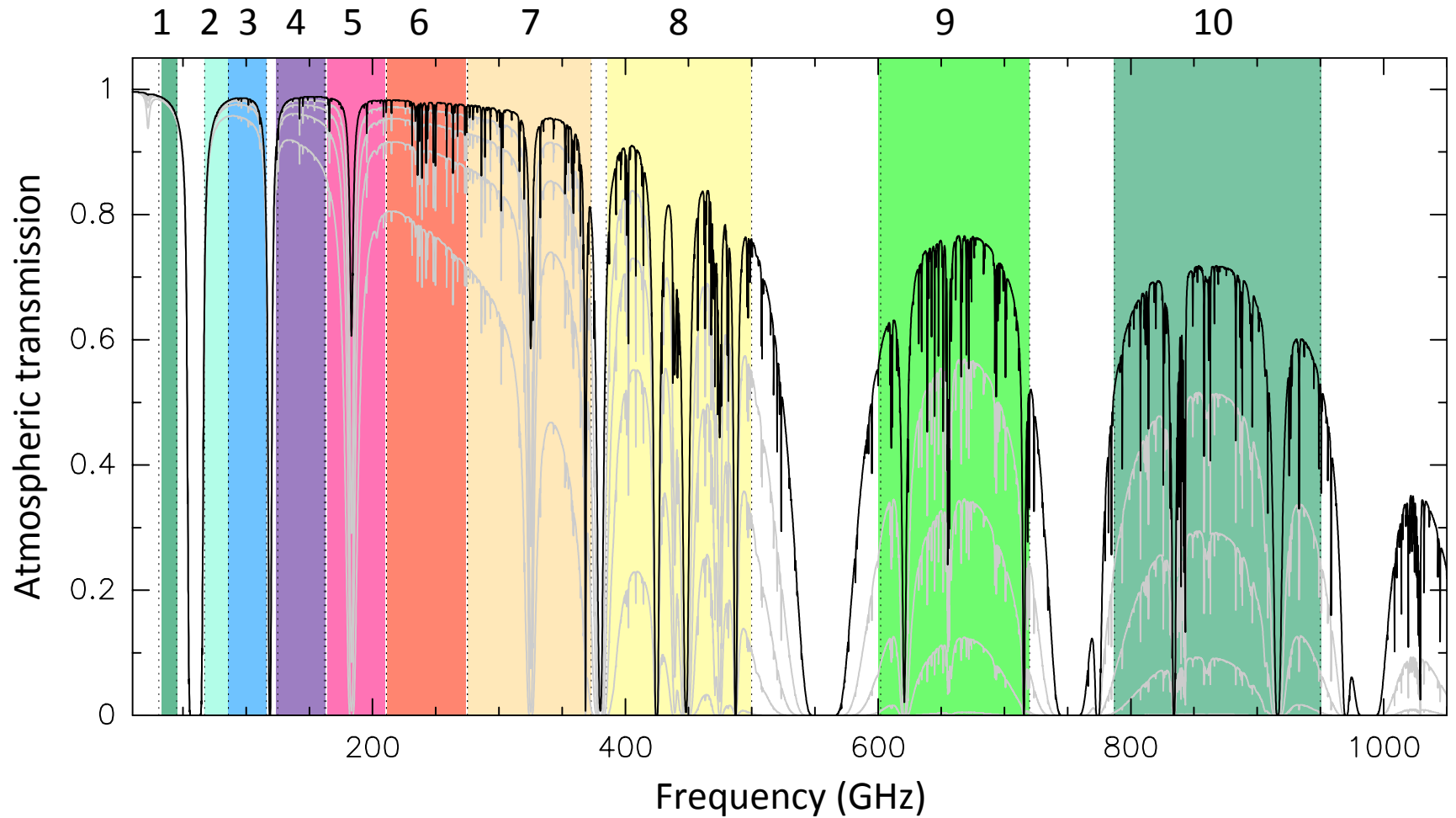
- frequency of the lines to observe
- velocity / redshift of the source
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- ...

## Spectral observations in a radio-interferometer

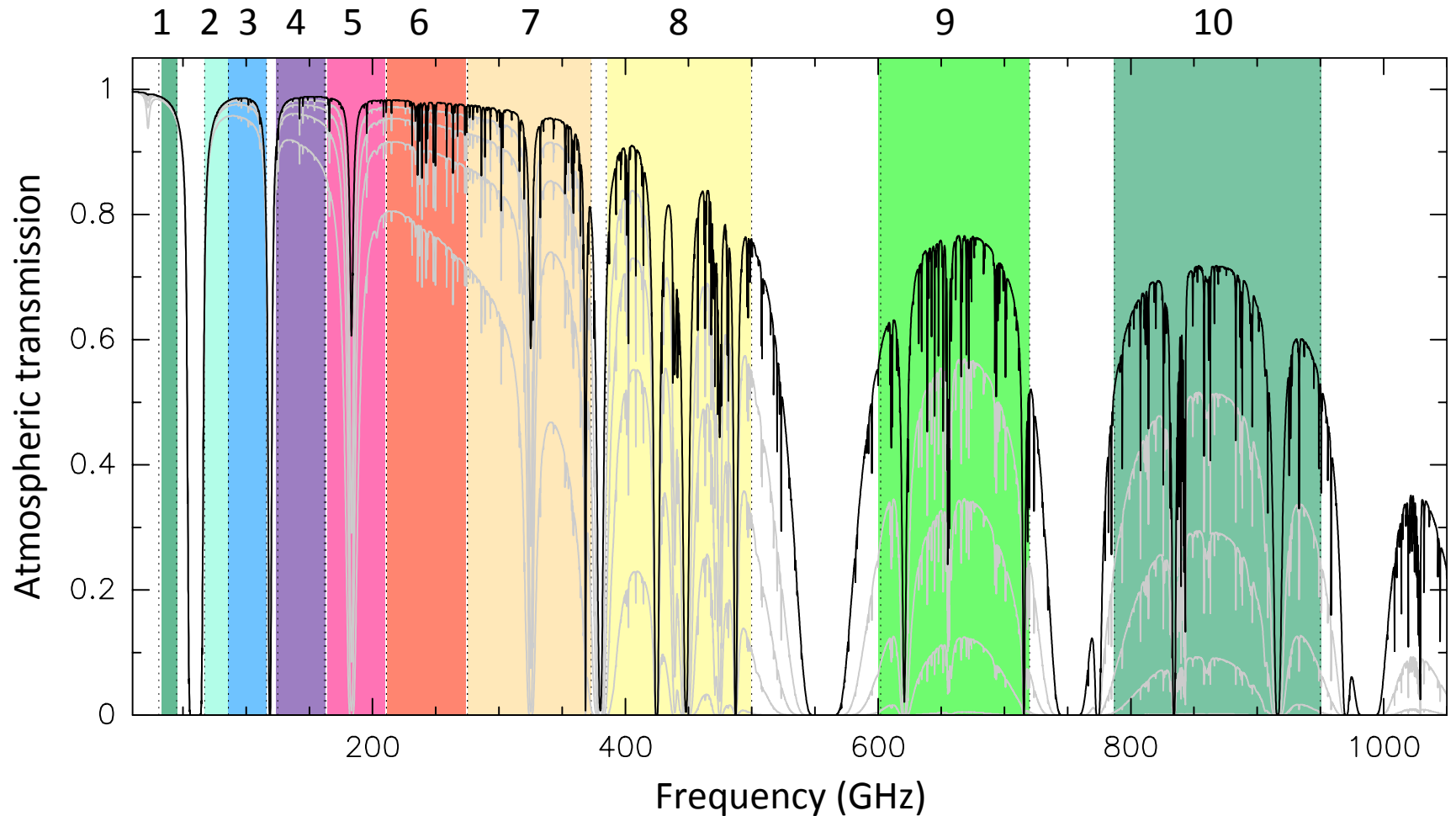
- **frequency bands**
- receivers
- spectral resolution (correlator)



# ALMA frequency bands



# ALMA frequency bands



**Band 3:** 84 – 116 GHz

**Band 4:** 125 – 163 GHz

**Band 5:** 159 – 211 GHz

**Band 6:** 211 – 275 GHz

**Band 7/8:** 275 – 373 GHz / 385 – 500 GHz

**Band 9/10:** 602 – 720 GHz / 787 – 950 GHz

# What do we need to know?

- frequency of the lines to observe
- velocity / redshift of the source
- line shape / velocity coverage and resolution
- ...

## Spectral observations in a radio-interferometer

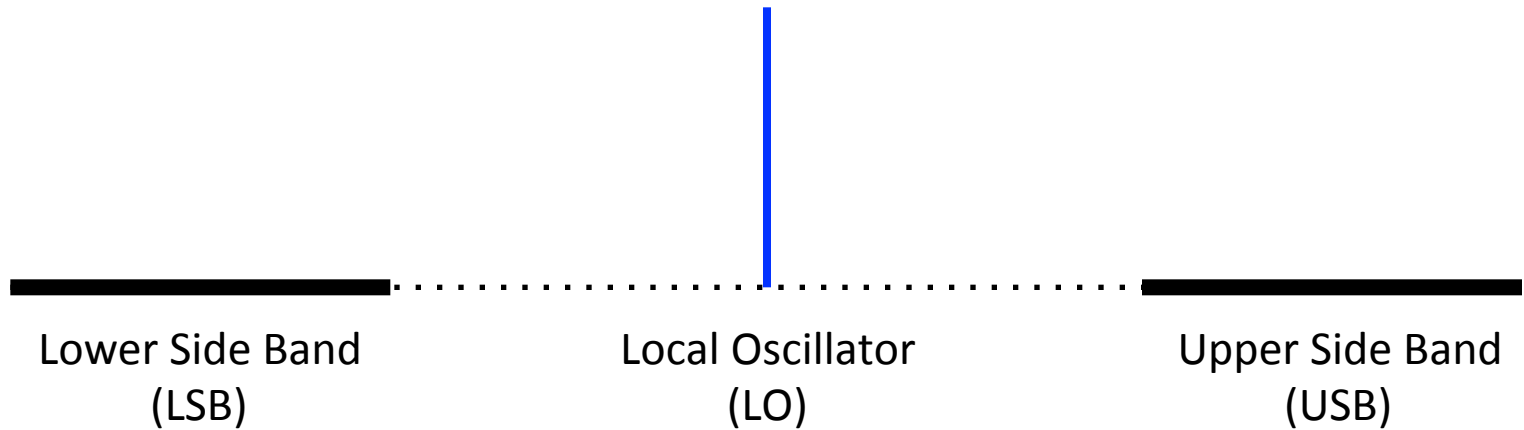
- frequency bands
- **receivers**
- spectral resolution (correlator)



# ALMA receivers

**Heterodyne** receivers

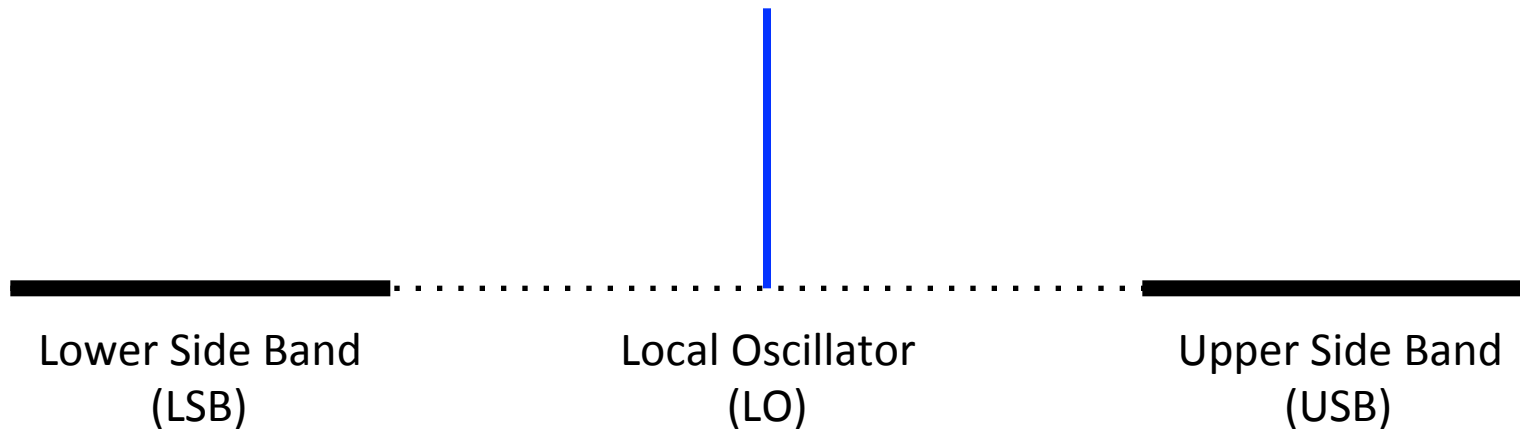
are sensitive to Lower Side Band (LSB) and Upper Side Band (USB)



# ALMA receivers

## Heterodyne receivers

are sensitive to Lower Side Band (LSB) and Upper Side Band (USB)



Heterodyne receivers can be:

**SSB** (single) outputs **LSB or USB**

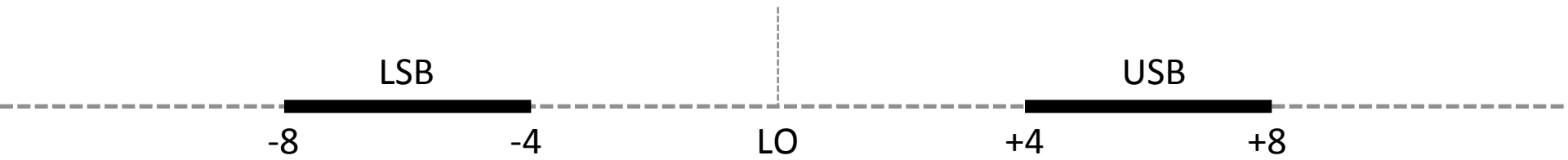
**DSB** (double) outputs the sum **LSB+USB** (separated in correlator)

**2SB** (two) outputs **LSB and USB** (separately)

# ALMA receivers

ALMA B3 / B4 / B5 / B7 / B8

2SB receivers 4-8 GHz

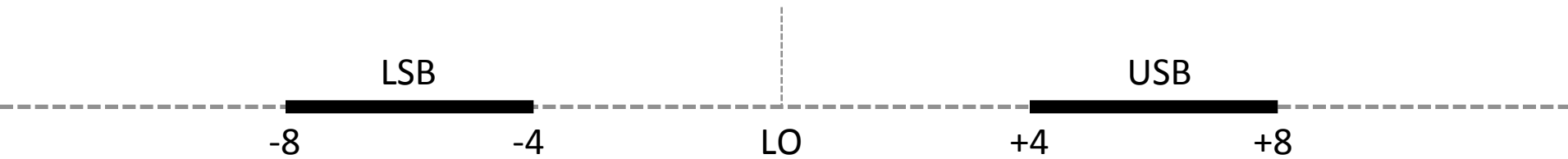




# ALMA receivers

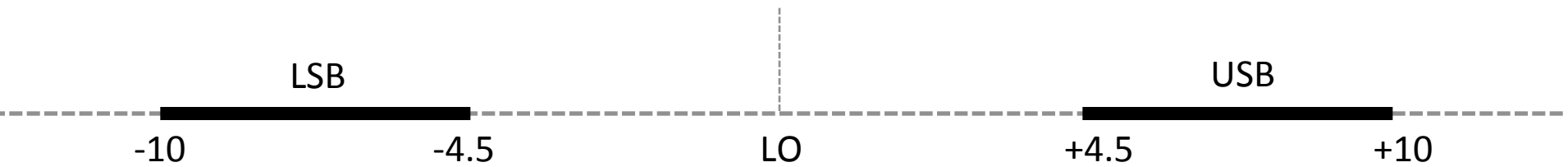
ALMA B3 / B4 / B5 / B7 / B8

2SB receivers 4-8 GHz



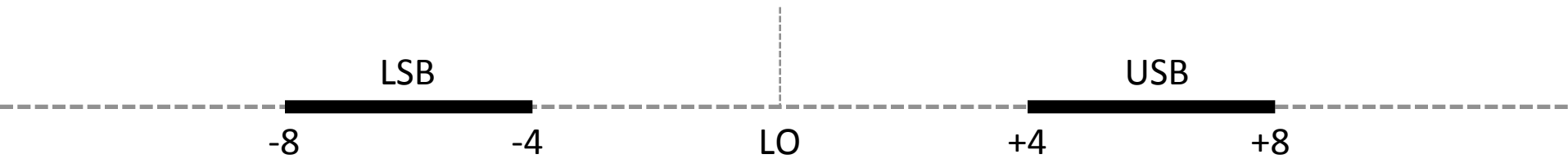
ALMA B6

2SB receivers 4.5-10 GHz

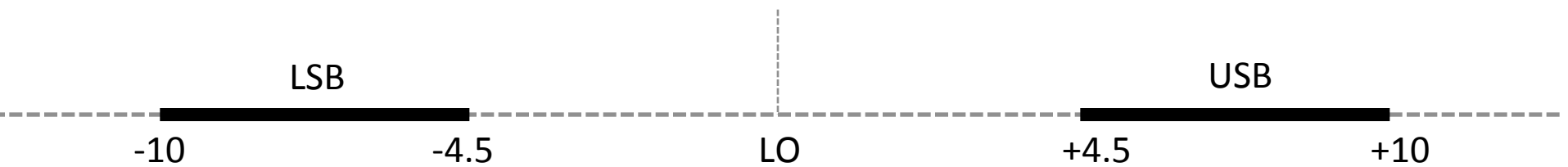


# ALMA receivers

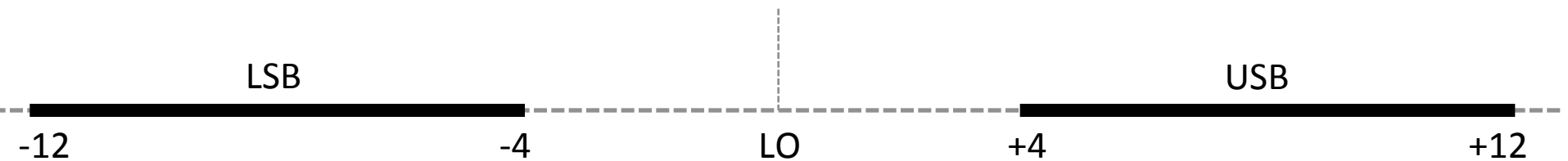
ALMA B3 / B4 / B5 / B7 / B8 2SB receivers 4-8 GHz



ALMA B6 2SB receivers 4.5-10 GHz



ALMA B9 / B10 DSB receivers 4-12 GHz



# ALMA frequency bands & receivers

Band 3: 84 – 116 GHz

Band 4: 125 – 163 GHz

Band 6: 211 – 275 GHz

Band 7: 275 – 373 GHz

Band 8: 385 – 500 GHz

Band 9/10: 602 – 720 GHz / 787 – 950 GHz

# ALMA frequency bands & receivers

**Band 3:** 84 – 116 GHz

Band 4: 125 – 163 GHz

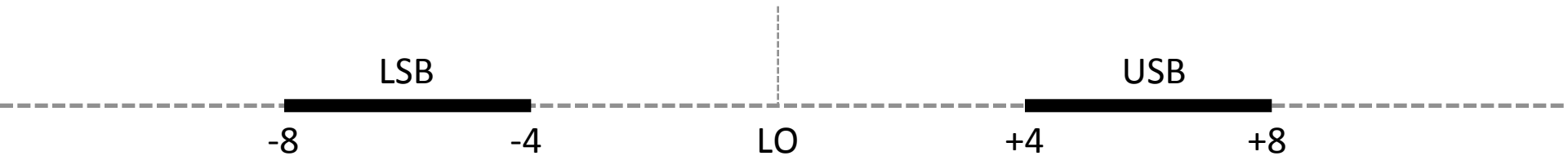
Band 6: 211 – 275 GHz

Band 7: 275 – 373 GHz

Band 8: 385 – 500 GHz

Band 9/10: 602 – 720 GHz / 787 – 950 GHz

**ALMA B3 / B4 / B5 / B7 / B8** 2SB receivers 4-8 GHz



# ALMA frequency bands & receivers

**Band 3:** 84 – 116 GHz

Band 4: 125 – 163 GHz

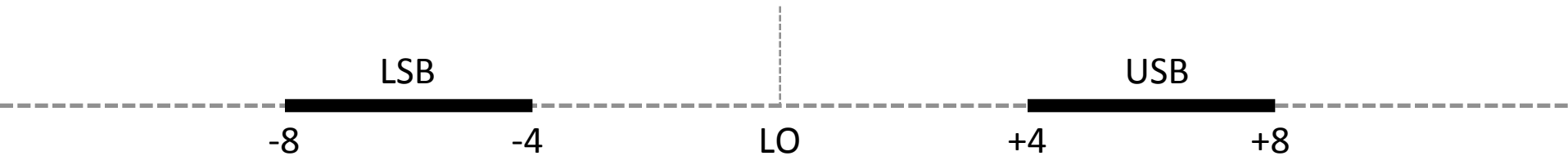
Band 6: 211 – 275 GHz

Band 7: 275 – 373 GHz

Band 8: 385 – 500 GHz

Band 9/10: 602 – 720 GHz / 787 – 950 GHz

**ALMA B3** / B4 / B5 / B7 / B8 2SB receivers 4-8 GHz



Band 3



# ALMA frequency bands & receivers

**Band 3:** 84 – 116 GHz

Band 4: 125 – 163 GHz

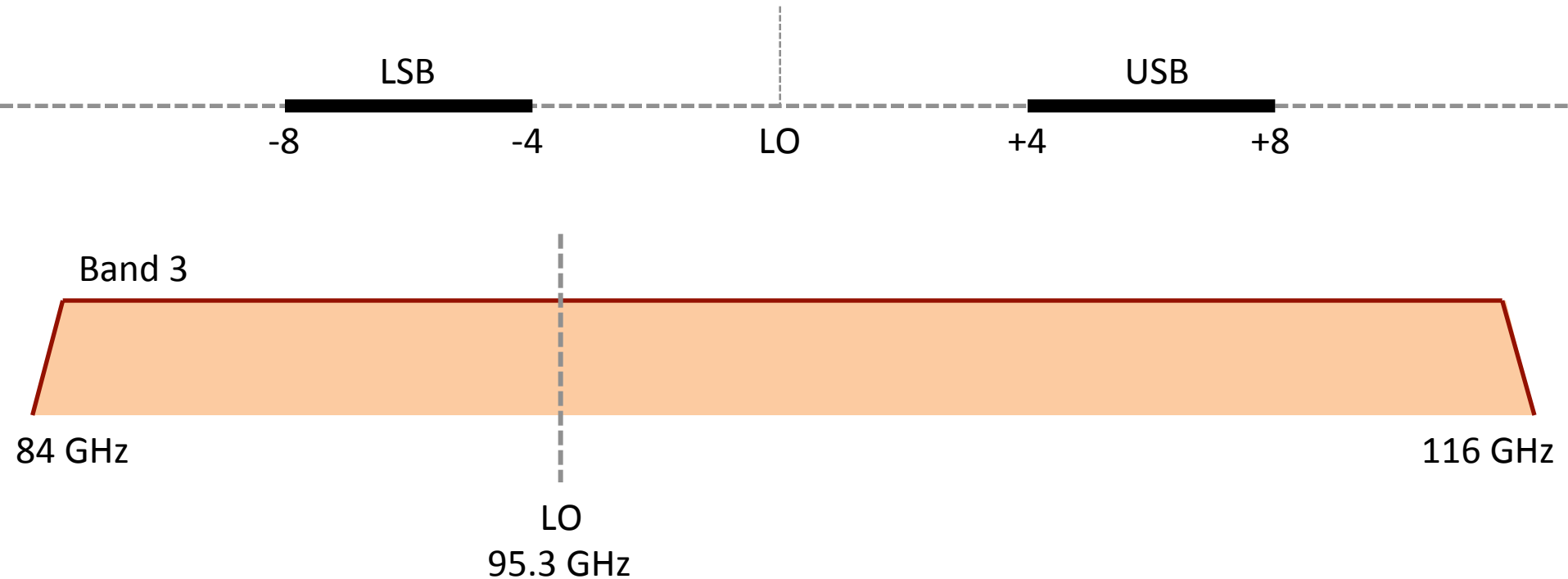
Band 6: 211 – 275 GHz

Band 7: 275 – 373 GHz

Band 8: 385 – 500 GHz

Band 9/10: 602 – 720 GHz / 787 – 950 GHz

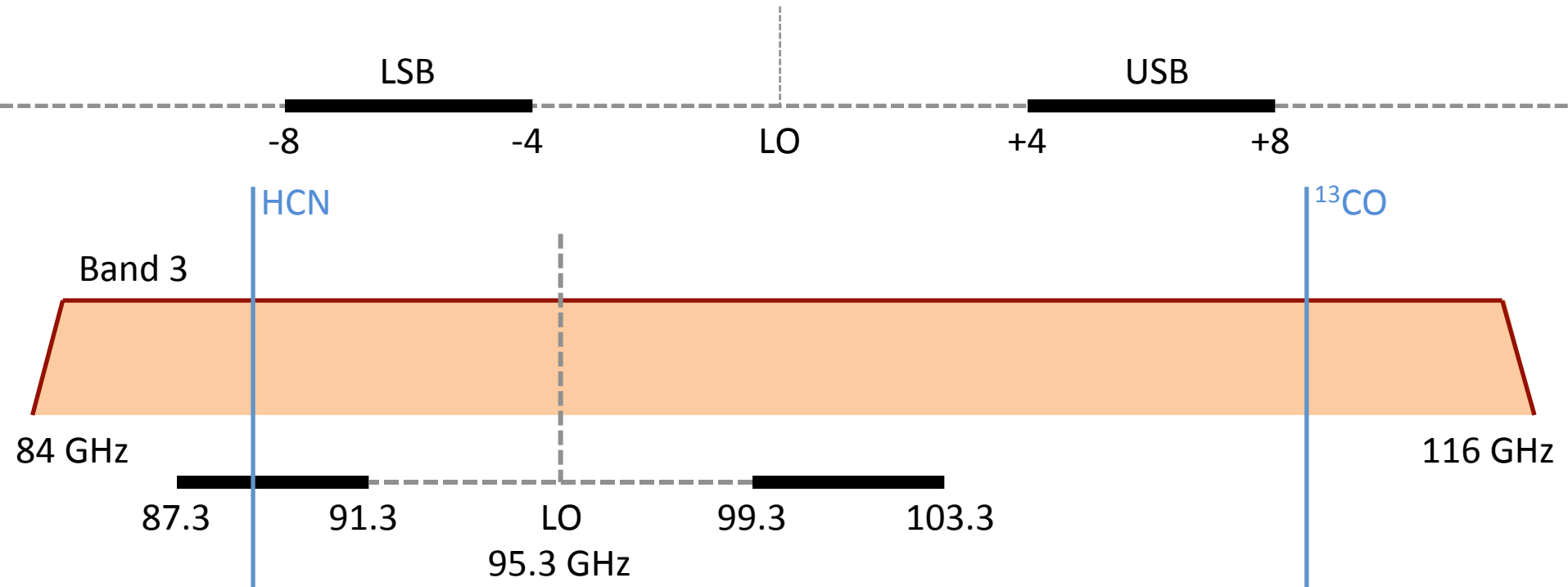
**ALMA B3** / B4 / B5 / B7 / B8 2SB receivers 4-8 GHz



# ALMA frequency bands & receivers

<b>Band 3:</b> 84 – 116 GHz	Band 7: 275 – 373 GHz
Band 4: 125 – 163 GHz	Band 8: 385 – 500 GHz
Band 6: 211 – 275 GHz	Band 9/10: 602 – 720 GHz / 787 – 950 GHz

**ALMA B3** / B4 / B5 / B7 / B8 2SB receivers 4-8 GHz





# ALMA frequency bands & receivers

**Band 3:** 84 – 116 GHz

Band 4: 125 – 163 GHz

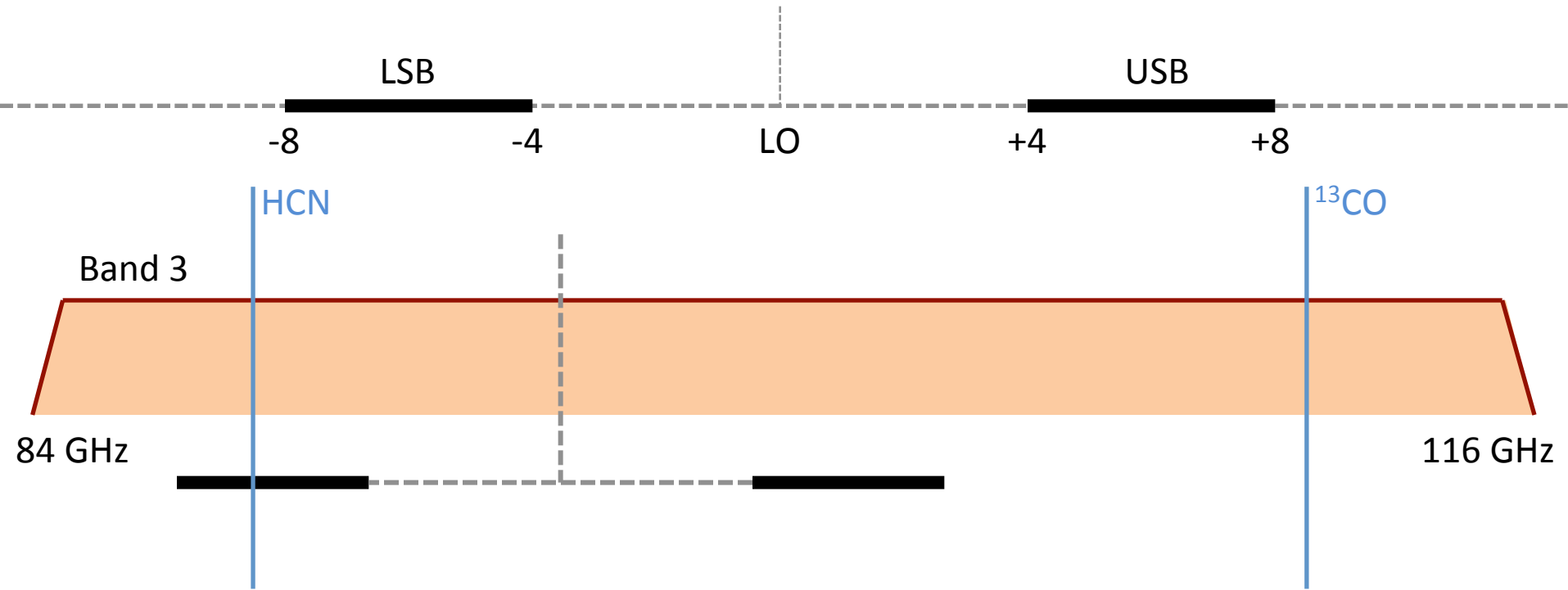
Band 6: 211 – 275 GHz

Band 7: 275 – 373 GHz

Band 8: 385 – 500 GHz

Band 9/10: 602 – 720 GHz / 787 – 950 GHz

**ALMA B3 / B4 / B5 / B7 / B8** 2SB receivers 4-8 GHz



# ALMA frequency bands & receivers

**Band 3:** 84 – 116 GHz

Band 4: 125 – 163 GHz

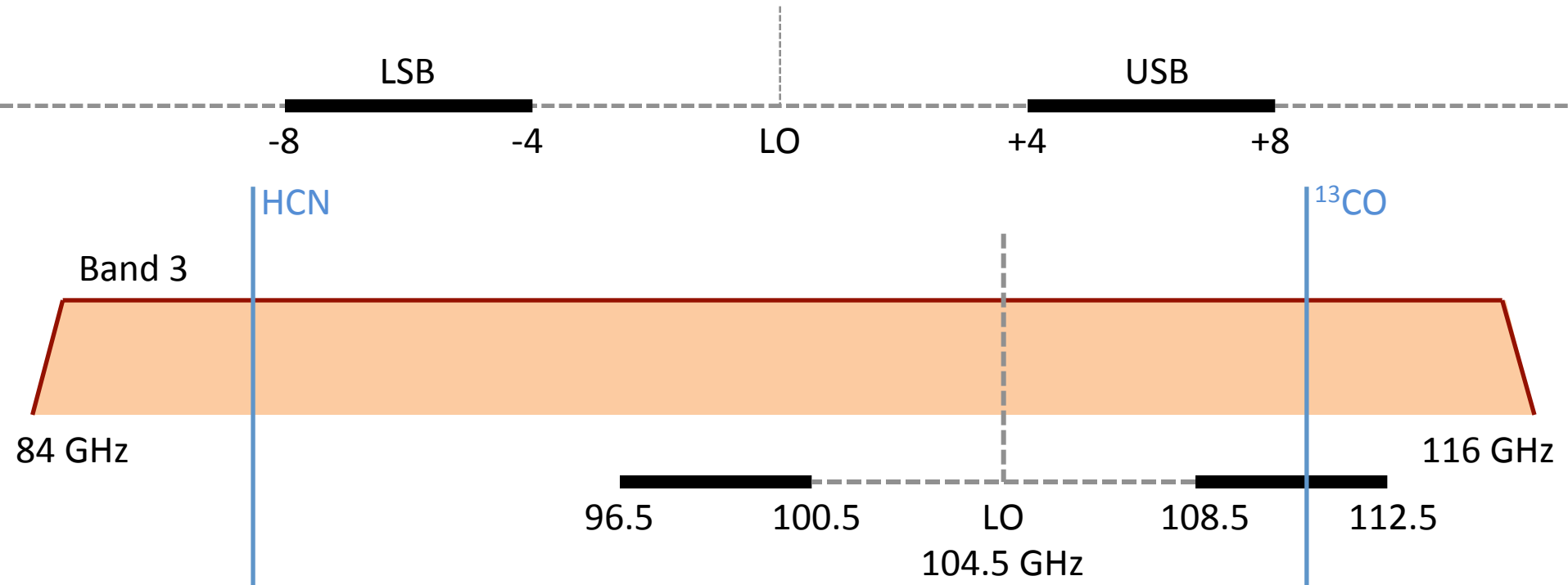
Band 6: 211 – 275 GHz

Band 7: 275 – 373 GHz

Band 8: 385 – 500 GHz

Band 9/10: 602 – 720 GHz / 787 – 950 GHz

**ALMA B3 / B4 / B5 / B7 / B8** 2SB receivers 4-8 GHz



# What do we need to know?

- frequency of the lines to observe
- velocity / redshift of the source
- line shape / velocity coverage and resolution
- ...

## Spectral observations in a radio-interferometer

- frequency bands
- receivers
- **spectral resolution (correlator)**



# ALMA correlator / 4 basebands

## basebands

information from 64 antennas

2 GHz input

up to 8192 channels

2 polarizations Horizontal / Vertical

up to 4 polarization products (HH, VV, HV, VH)

# ALMA correlator / 4 basebands

## basebands

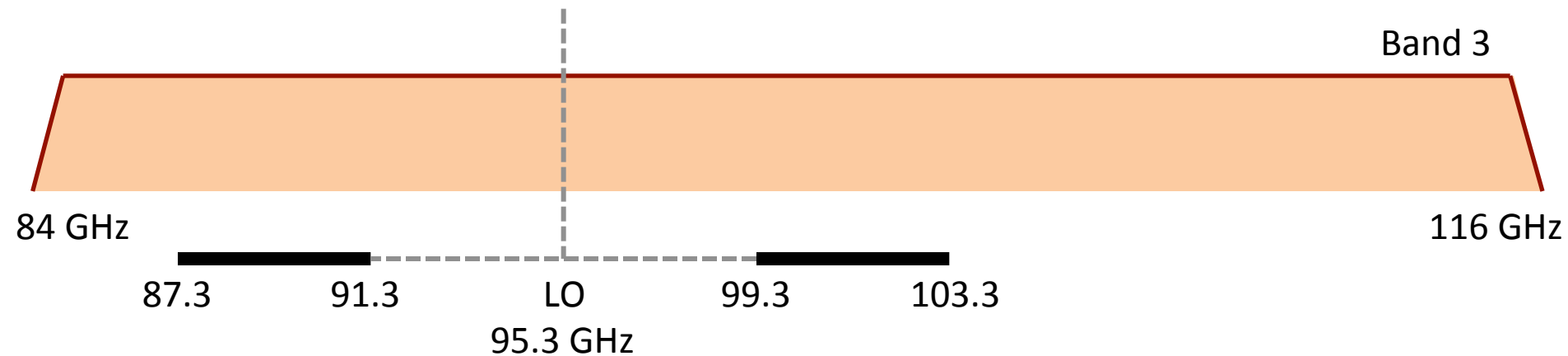
information from 64 antennas

2 GHz input

up to 8192 channels

2 polarizations Horizontal / Vertical

up to 4 polarization products (HH, VV, HV, VH)



# ALMA correlator / 4 basebands

## basebands

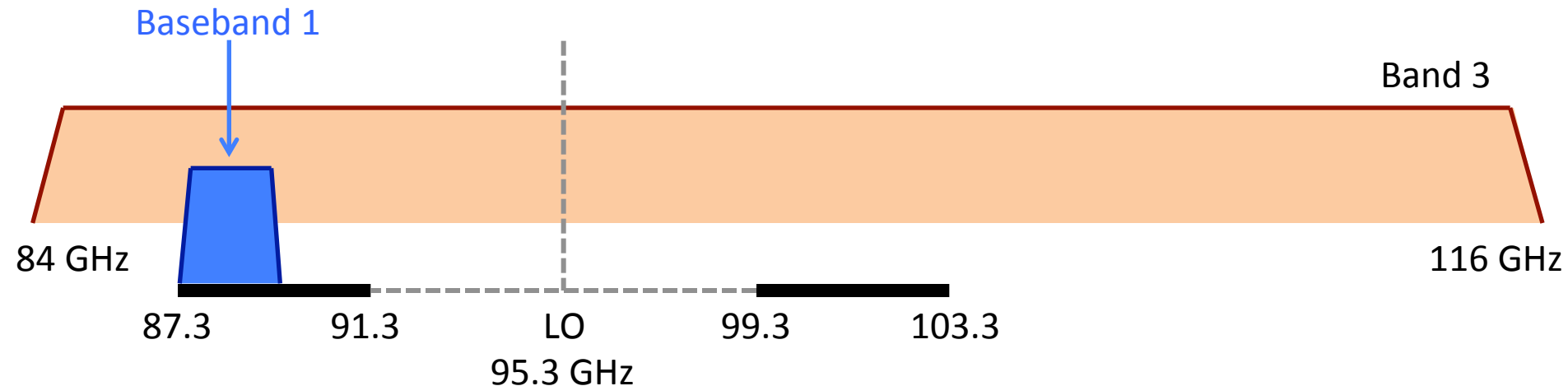
information from 64 antennas

**2 GHz** input

up to 8192 channels

2 polarizations Horizontal / Vertical

up to 4 polarization products (HH, VV, HV, VH)



# ALMA correlator / 4 basebands

## basebands

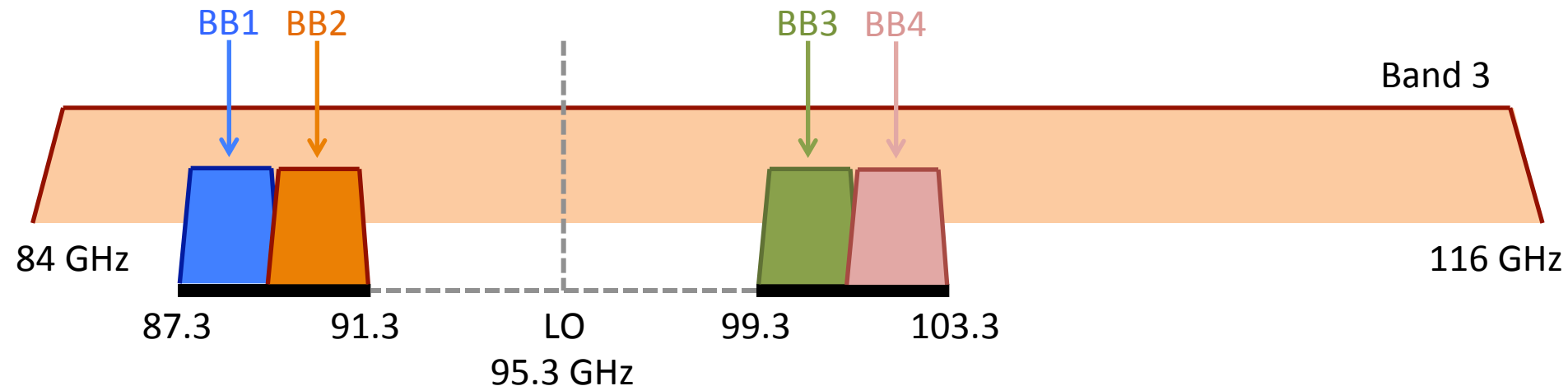
information from 64 antennas

**2 GHz** input

up to 8192 channels

2 polarizations Horizontal / Vertical

up to 4 polarization products (HH, VV, HV, VH)





# ALMA correlator / 4 basebands

## basebands

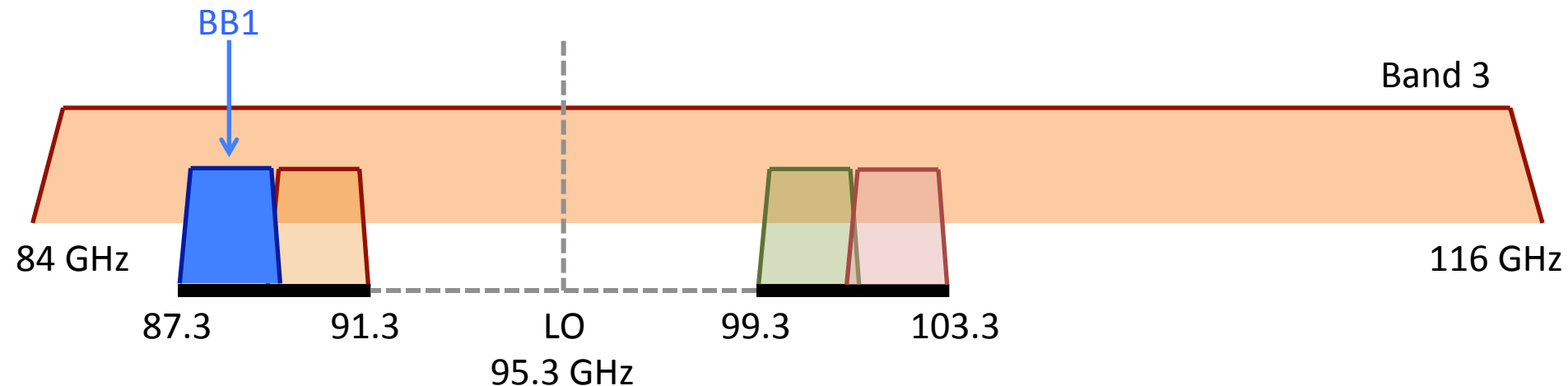
information from 64 antennas

**2 GHz** input

up to 8192 channels

2 polarizations Horizontal / Vertical

up to 4 polarization products (HH, VV, HV, VH)



# ALMA correlator / **4 basebands**

## basebands

information from 64 antennas

**2 GHz** input

up to 8192 channels

2 polarizations Horizontal / Vertical

up to 4 polarization products (HH, VV, HV, VH)

Baseband 1



87.3 GHz

89.3 GHz

# ALMA correlator / **4 basebands**

## basebands

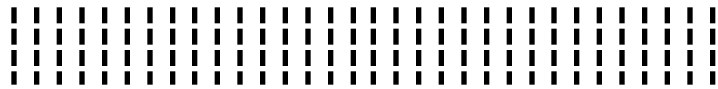
information from 64 antennas

**2 GHz** input

up to **8192 channels**

2 polarizations Horizontal / Vertical

up to 4 polarization products (HH, VV, HV, VH)



... up to 8192 channels

Baseband 1



87.3 GHz

89.3 GHz

# ALMA correlator / **4 basebands**

## basebands

information from 64 antennas

**2 GHz** input

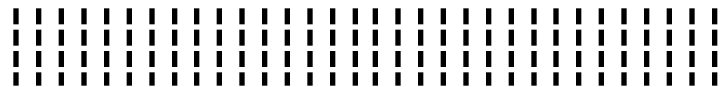
up to **8192 channels**

2 polarizations Horizontal / Vertical

up to 4 polarization products (HH, VV, HV, VH)

channel width (**spectral resolution**):

$$2 \text{ GHz} / 8192 = 244 \text{ kHz (0.8 km/s)}$$



Baseband 1

87.3 GHz

89.3 GHz

# ALMA correlator / 4 basebands

## basebands

information from 64 antennas

**2 GHz** input

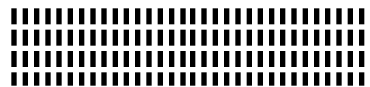
up to **8192 channels**

2 polarizations Horizontal / Vertical

up to 4 polarization products (HH, VV, HV, VH)

channel width (**spectral resolution**):

$$1 \text{ GHz} / 8192 = 122 \text{ kHz (0.4 km/s)}$$



... up to 8192 channels

Baseband 1



87.3 GHz

88.3 GHz

# ALMA correlator / 4 basebands

## basebands

information from 64 antennas

**2 GHz** input

up to **8192 channels**

2 polarizations Horizontal / Vertical

up to 4 polarization products (HH, VV, HV, VH)

channel width (**spectral resolution**):

$$64 \text{ MHz} / 8192 = 7.5 \text{ kHz (0.025 km/s)}$$



... up to 8192 channels

Baseband 1



87.3 87.6  
GHz GHz

# ALMA correlator / 4 basebands

## basebands

information from 64 antennas

**2 GHz** input

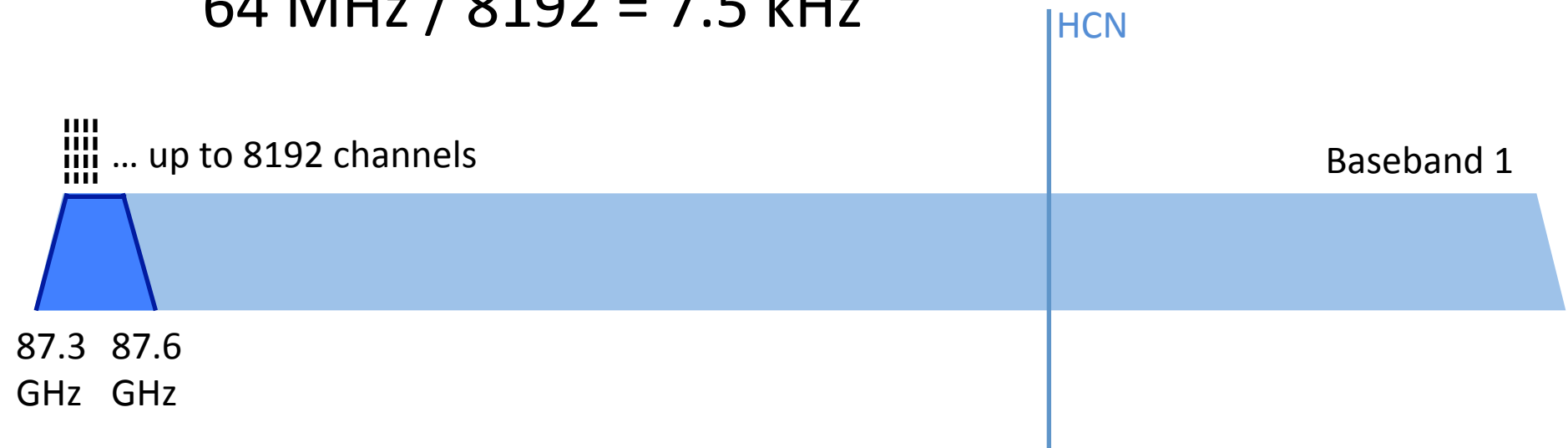
up to **8192 channels**

2 polarizations Horizontal / Vertical

up to 4 polarization products (HH, VV, HV, VH)

channel width (**spectral resolution**):

$$64 \text{ MHz} / 8192 = 7.5 \text{ kHz}$$



# ALMA correlator / 4 basebands

## basebands

information from 64 antennas

**2 GHz** input

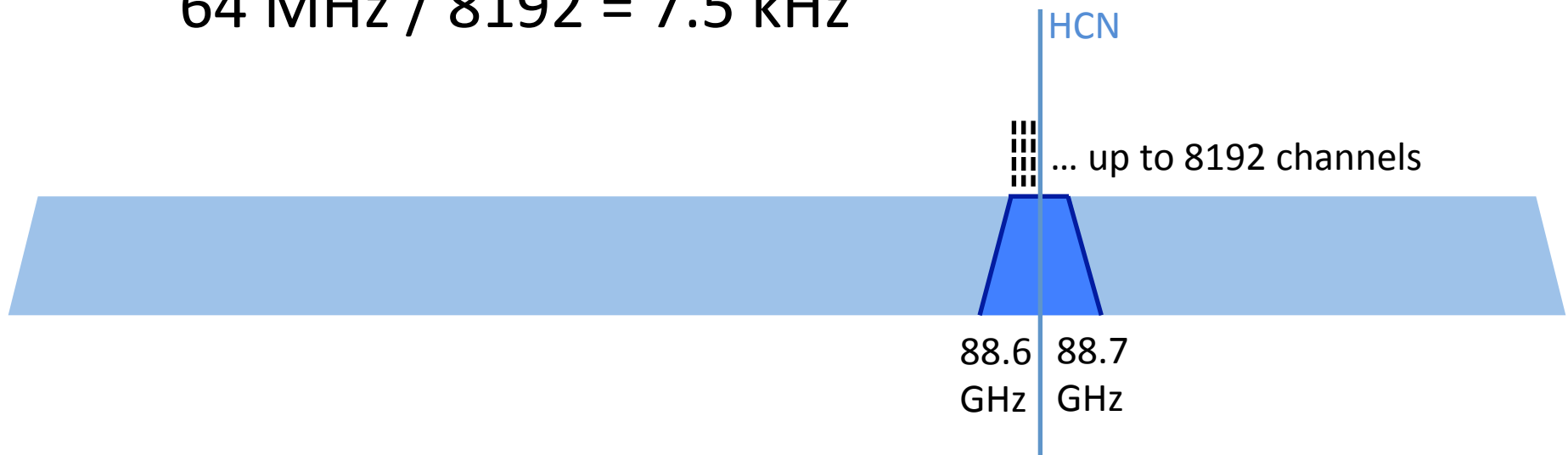
up to **8192 channels**

2 polarizations Horizontal / Vertical

up to 4 polarization products (HH, VV, HV, VH)

channel width (**spectral resolution**):

$$64 \text{ MHz} / 8192 = 7.5 \text{ kHz}$$

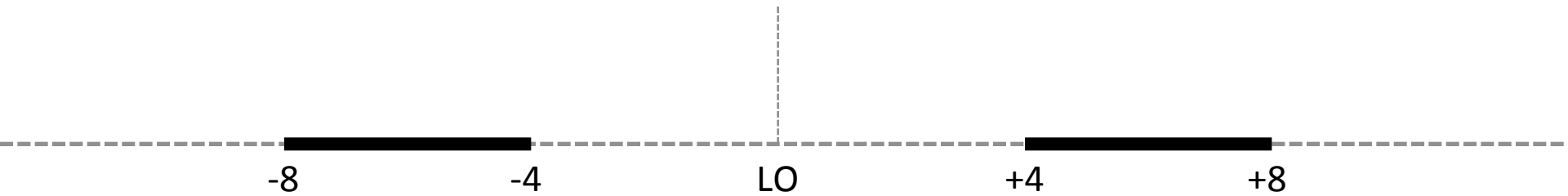




# ALMA correlator (examples)

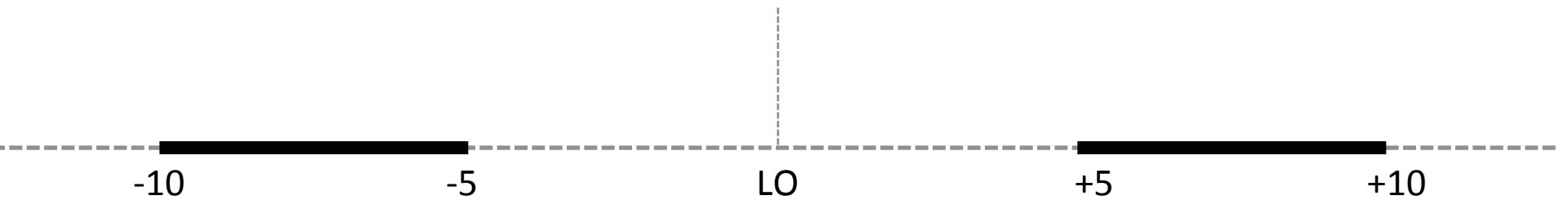
ALMA B3 / B4 / B5 / B7 / B8

2SB receivers 4-8 GHz



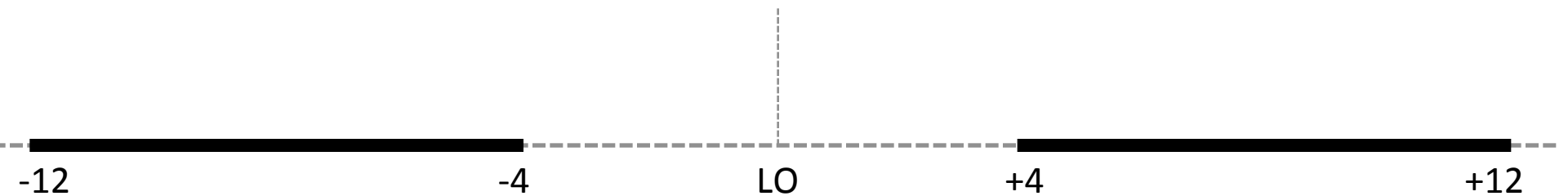
ALMA B6

2SB receivers 4.5-10 GHz



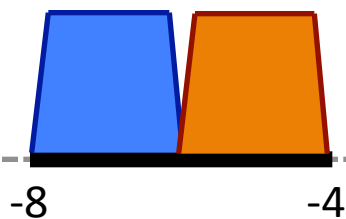
ALMA B9 / B10

DSB receivers 4-12 GHz

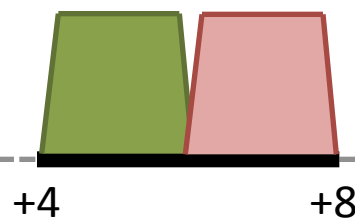


# ALMA correlator (examples)

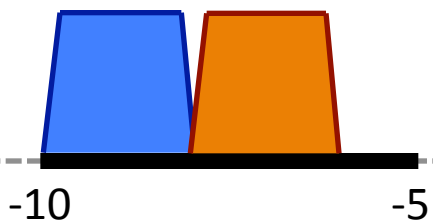
ALMA B3 / B4 / B5 / B7 / B8



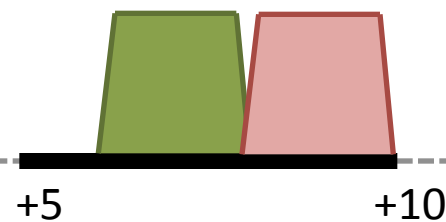
2SB receivers 4-8 GHz



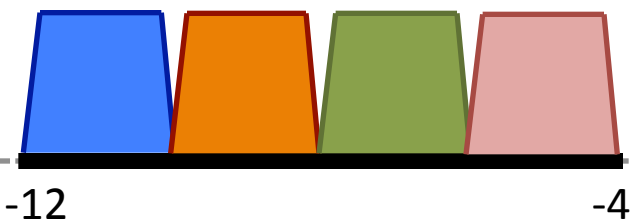
ALMA B6



2SB receivers 4.5-10 GHz



ALMA B9 / B10

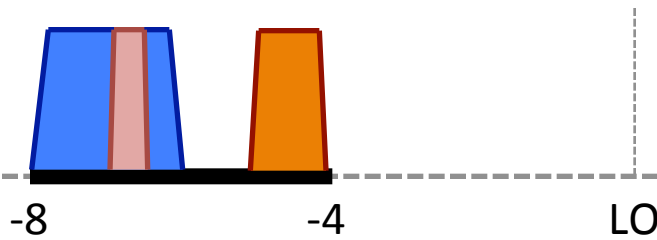


DSB receivers 4-12 GHz

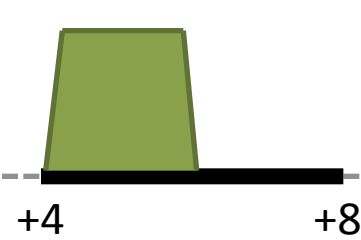


# ALMA correlator (examples)

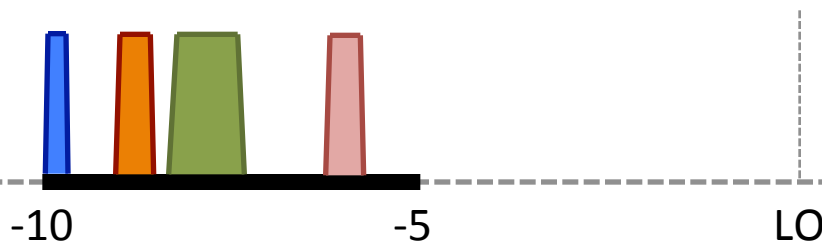
ALMA B3 / B4 / B5 / B7 / B8



2SB receivers 4-8 GHz



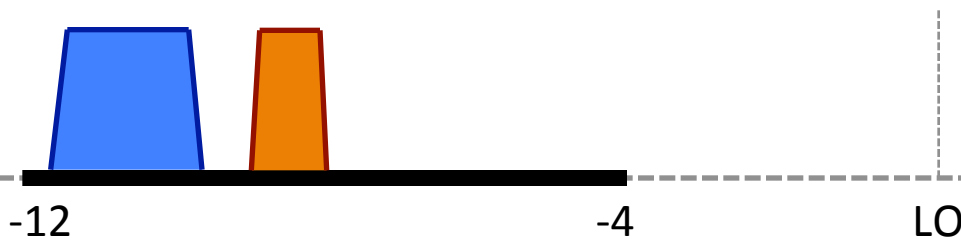
ALMA B6



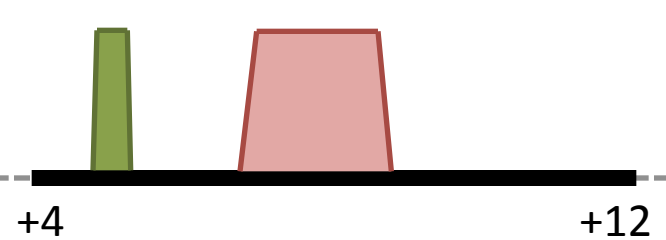
2SB receivers 4.5-10 GHz



ALMA B9 / B10



DSB receivers 4-12 GHz



# Spectral setup in the almaOT (**EXAMPLE**)

We want to observe three lines in our target:

HCN(1-0), HCO<sup>+</sup>(1-0) and H<sup>13</sup>CO<sup>+</sup>(1-0)

# Spectral setup in the almaOT (EXAMPLE)

We want to observe three lines in our target:

HCN(1-0), HCO<sup>+</sup>(1-0) and H<sup>13</sup>CO<sup>+</sup>(1-0)

From previous observations we know the approximate linewidth:

HCN(1-0)      →  $\Delta v = 7$  km/s

HCO<sup>+</sup>(1-0)    →  $\Delta v = 10$  km/s

H<sup>13</sup>CO<sup>+</sup>(1-0) →  $\Delta v = 3$  km/s

# Spectral setup in the almaOT (EXAMPLE)

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H<sup>13</sup>CO<sup>+</sup>(1-0) →  $\Delta v = 3$  km/s

For our ALMA observations we would need:

**Bandwidth** > 20 km/s to properly cover the extend of the lines

**Resolution** < 0.7 km/s for the HCN and HCO<sup>+</sup> lines

< 0.3 km/s for the H<sup>13</sup>CO<sup>+</sup> line

# Spectral setup in the almaOT (EXAMPLE)

The screenshot displays the ALMA Observing Tool (Cycle3) interface. The title bar shows "ALMA Observing Tool (Cycle3-Patchtests2) - Project" and the system tray includes the date "Sun Mar 22 14:16" and the user name "Alvaro Sanchez". The menu bar contains "File", "Edit", "View", "Tool", "Search", and "Help". The toolbar includes icons for file operations, settings, and navigation.

The interface is divided into two main panes. The left pane, titled "Project Structure", shows a tree view of the project hierarchy: "Unsubmitted Proposal" > "Project" > "Proposal" > "Planned Observations" > "Science Goals" > "Spectral". The right pane, titled "Editors", has three tabs: "Spectral", "Spatial", and "Spectral Setup". The "Spectral Setup" tab is active.

The "Spectral Setup" tab contains the following information:

- A text box explaining that up to 16 spectral windows can be defined, 4 per baseband, with a total fraction per baseband not exceeding 1. Each baseband is 2GHz wide and can be separately configured.
- A "Spectral Type" section with radio buttons for "Spectral Line" (selected), "Single Continuum", and "Spectral Scan".
- A "Polarization products desired" section with radio buttons for "XX", "DUAL" (selected), and "FULL".
- A "Spectral Setup Errors" section with a red message: "No spectral window in the list. No suitable receiver band for the range :[0.0 GHz, 0.0 GHz]".
- A "Spectral Line" section with a table for Baseband-1:

Fraction	Center Freq (Rest)	Center Freq (Sky)	Transition	Bandwidth, Resolution (smoothed)	Spec Avg.	Representative Window

Below the table are buttons for "Select Lines to Observe in Baseband-1...", "Add", and "Delete". Similar sections for Baseband-2 and Baseband-3 are visible below.

# Spectral setup in the almaOT (EXAMPLE)

ALMA Observing Tool (Cycle3)

ALMA Observing Tool (Cycle3-Patchtests2) - Project

File Edit View Tool Search Help

Perspective 1

**Project Structure**

- Unsubmitted Proposal
  - Project
    - Proposal
      - Planned Observations
        - Science Goals
          - General
          - Field Set
          - Spectral**
          - Calibration
          - Control
          - Technical

**Editors**

Spectral Spatial Spectral Setup

In the table below, it is possible to define up to 16 spectral windows, 4 per baseband as long as the total Fraction per baseband is no more than 1. Each baseband is 2GHz wide and can be separately configured i.e. each spectral window can have a different bandwidth and resolution. Note that for bands 3, 4, 6, 7 and 8, it is not possible to put 3 basebands in one sideband and the fourth one in the other.

Spectral Type [?] -

Spectral Line  
 Single Continuum  
 Spectral Scan

Polarization products desired  XX  DUAL  FULL

Spectral Setup Errors  
No spectral window in the list. No suitable receiver band for the range :[0.0 GHz, 0.0 GHz]

Spectral Line [?] -

Baseband-1 [?] -

Fraction	Center Freq (Rest)	Center Freq (Sky)	Transition	Bandwidth, Resolution (smoothed)	Spec Avg.	Representative Window

Select Lines to Observe in Baseband-1... Add Delete

Baseband-2

Select Lines to Observe in Baseband-2... Add Delete

Baseband-3



# Spectral setup in the almaOT (EXAMPLE)

ALMA Observing Tool (Cycle3) Sun Mar 22 14:18 Alvaro Sanchez

ALMA Observing Tool (Cycle3-Patchtests2) - Project  
Select Spectral Lines

**Transition Filter**

e.g. CO\*2-1\* or \*oxide\*

Include description

**Frequency Filters**

**ALMA Band**

1 2 3 4 5 6 7 8 9 10

**Sky Frequency (GHz)**

Min  Max

**Receiver/Back End Configuration**

Hide unobservable lines

Filtering unobservable lines

**Maximum Upper-state Energy (K)**

0 20 40 60 80 100 ∞

**Molecule Filter / Environment**

Show

Can't find the transition you're looking for in the offline pool? Find more in the online Splatalogue.

**Transitions matching your filter settings:**  
(double-click column header for primary sort, single-click subsequent columns for secondary sorting. Single clicks will reverse sort order of already selected transitions.)

Transition $\triangle$	Description	Rest Freq... $\triangle$	Sky Frequ...	Upper-state E...	Lovas Inte...	Sij $\mu^2$
I-C5H J=35/2-33/2, $\Omega=3/2$ , F=17-16, l=f	2,4-Pentadiynylidyne	84.108 GHz	84.108 G...	71.861 K	4.7	401.709
I-C5H J=35/2-33/2, $\Omega=3/2$ , F=18-17, l=f	2,4-Pentadiynylidyne	84.108 GHz	84.108 G...	71.861 K	4.7	425.314
I-C5H J=35/2-33/2, $\Omega=3/2$ , F=17-16, l=e	2,4-Pentadiynylidyne	84.11 GHz	84.11 GHz	71.862 K		401.692
I-C5H J=35/2-33/2, $\Omega=3/2$ , F=18-17, l=e	2,4-Pentadiynylidyne	84.11 GHz	84.11 GHz	71.862 K		425.395
C4H v7 = 1 J=17/2-15/2, $\Omega=1/2$ , l=f	1,3-Butadiynyl radical	84.123 GHz	84.123 G...	211.671 K	2.1	12.771 [
CH3OH v t=1 11(10,1)-11(11,0)	Methanol	84.159 GHz	84.159 G...	1066.119 K		1.459 D <sup>2</sup>
U-84163	UNIDENTIFIED	84.163 GHz	84.163 G...		0.06	
30SiO v=1 2-1	Silicon Monoxide	84.164 GHz	84.164 G...	1753.828 K		19.441 [
C-H13CCCH 2(1,2)-1(0,1)	Cyclopropenylidene	84.186 GHz	84.186 G...	6.331 K	0.13	17.24 D <sup>2</sup>
U-84215	UNIDENTIFIED	84.215 GHz	84.215 G...		0.08	
SO2 v=0 32(5,27)-31(6,26)	Sulfur dioxide	84.321 GHz	84.321 G...	549.36 K	0.1	13.463 [
U-84356	UNIDENTIFIED	84.356 GHz	84.356 G...		0.07	
U-84385	UNIDENTIFIED	84.385 GHz	84.385 G...		0.08	
34SO 2(2)-1(1)	Sulfur Monoxide	84.411 GHz	84.411 G...	19.233 K	0.03	3.534 D <sup>2</sup>
CH3OH v t=0 13(-3,11)-14(-2,13)	Methanol	84.424 GHz	84.424 G...	273.898 K		4.303 D <sup>2</sup>
13CH3OH v t=0 13(-3,11)-12(-4,9)	Methanol	84.444 GHz	84.444 G...	269.033 K		3.267 D <sup>2</sup>
U-84468	UNIDENTIFIED	84.468 GHz	84.468 G...		0.18	
U-84478	UNIDENTIFIED	84.478 GHz	84.478 G...		0.18	
U-84496	UNIDENTIFIED	84.496 GHz	84.496 G...		0.1	
CH3OH v t=0 5(-1,5)-4(0,4)	Methanol	84.521 GHz	84.521 G...	40.391 K		3.083 D <sup>2</sup>
CH3OH v t=1 12(10,2)-12(11,1)	Methanol	84.54 GHz	84.54 GHz	1093.861 K		2.786 D <sup>2</sup>
NH2CHO 4(0,4)-3(0,3)	Formamide	84.542 GHz	84.542 G...	10.158 K	0.21	52.272 [
C6H J=61/2-59/2, $\Omega=3/2$ , l=e	1,3,5-Hexatriynyl	84.55 GHz	84.55 GHz	63.662 K	0.04	1867.72
CH3OH v t=0 19(2,17)-18(-3,16)	Methanol	84.574 GHz	84.574 G...	463.489 K		0.424 D <sup>2</sup>
C6H l=61/2-59/2, $\Omega=3/2$ , l=f	1.3.5-Hexatriynyl	84.575 GHz	84.575 G...	63.675 K	0.03	1867.56

Add to Selected Transitions

---

**Selected transitions**

Transition $\triangle$	Description	Rest Frequency $\triangle$	Sky Frequency

Remove from Selected Transitions

# Spectral setup in the almaOT (EXAMPLE)

ALMA Observing Tool (Cycle3) Sun Mar 22 14:18 Alvaro Sanchez

ALMA Observing Tool (Cycle3-Patchtests2) - Project  
Select Spectral Lines

**Transition Filter**

e.g. CO\*2-1\**not*\*oxide\*

Include description

**Frequency Filters**

**ALMA Band**

1 2 3 4 5 6 7 8

**Sky Frequency (GHz)**

Min  Max

**Receiver/Back End Configuration**

Hide unobservable lines

Filtering unobservable lines

**Maximum Upper-state Energy (K)**

0 20 40 60 80 100 ∞

**Molecule Filter / Environment**

Show

Can't find the transition you're looking for in the offline pool? Find more in the online Splatalogue.

**Transitions matching your filter settings:**  
(double-click column header for primary sort, single-click subsequent columns for secondary sorting. Single clicks will reverse sort order of already selected)

Transition ^	Description	Rest Freq... ^	Sky Freq...	Upper-state E...	Lovas Inte...	Sij μ <sup>2</sup>
I-C5H J=35/2-33/2, Ω=3/2, F=17-16, l=f	2,4-Pentadiynylidyne	84.108 GHz	84.108 G...	71.861 K	4.7	401.709
I-C5H J=35/2-33/2, Ω=3/2, F=18-17, l=f	2,4-Pentadiynylidyne	84.108 GHz	84.108 G...	71.861 K	4.7	425.314
I-C5H J=35/2-33/2, Ω=3/2, F=17-16, l=e	2,4-Pentadiynylidyne	84.11 GHz	84.11 GHz	71.862 K		401.692
I-C5H J=35/2-33/2, Ω=3/2, F=18-17, l=e	2,4-Pentadiynylidyne	84.11 GHz	84.11 GHz	71.862 K		425.395
C4H v7 = 1 J=17/2-15/2, Ω=1/2, l=f	1,3-Butadiynyl radical	84.123 GHz	84.123 G...	211.671 K	2.1	12.771 [
CH3OH v t=1 11(10,1)-11(11,0)	Methanol	84.159 GHz	84.159 G...	1066.119 K		1.459 D <sup>2</sup>
U-84163	UNIDENTIFIED	84.163 GHz	84.163 G...		0.06	
SiO v=1 2-1	Silicon Monoxide	84.164 GHz	84.164 G...	1753.828 K		19.441 [
U-84165	Cyclopropenylidene	84.186 GHz	84.186 G...	6.331 K	0.13	17.24 D <sup>2</sup>
U-84165	UNIDENTIFIED	84.215 GHz	84.215 G...		0.08	
SO2 v=0 32(5,27)-31(6,26)	Sulfur dioxide	84.321 GHz	84.321 G...	549.36 K	0.1	13.463 [
U-84356	UNIDENTIFIED	84.356 GHz	84.356 G...		0.07	
U-84385	UNIDENTIFIED	84.385 GHz	84.385 G...		0.08	
34SO 2(2)-1(1)	Sulfur Monoxide	84.411 GHz	84.411 G...	19.233 K	0.03	3.534 D <sup>2</sup>
CH3OH v t=0 13(-3,11)-14(-2,13)	Methanol	84.424 GHz	84.424 G...	273.898 K		4.303 D <sup>2</sup>
13CH3OH v t=0 13(-3,11)-12(-4,9)	Methanol	84.444 GHz	84.444 G...	269.033 K		3.267 D <sup>2</sup>
U-84468	UNIDENTIFIED	84.468 GHz	84.468 G...		0.18	
U-84478	UNIDENTIFIED	84.478 GHz	84.478 G...		0.18	
U-84496	UNIDENTIFIED	84.496 GHz	84.496 G...		0.1	
CH3OH v t=0 5(-1,5)-4(0,4)	Methanol	84.521 GHz	84.521 G...	40.391 K		3.083 D <sup>2</sup>
CH3OH v t=1 12(10,2)-12(11,1)	Methanol	84.54 GHz	84.54 GHz	1093.861 K		2.786 D <sup>2</sup>
NH2CHO 4(0,4)-3(0,3)	Formamide	84.542 GHz	84.542 G...	10.158 K	0.21	52.272 [
C6H J=61/2-59/2, Ω=3/2, l=e	1,3,5-Hexatriynyl	84.55 GHz	84.55 GHz	63.662 K	0.04	1867.72
CH3OH v t=0 19(2,17)-18(-3,16)	Methanol	84.574 GHz	84.574 G...	463.489 K		0.424 D <sup>2</sup>
C6H l=61/2-59/2, Ω=3/2, l=f	1.3.5-Hexatriynyl	84.575 GHz	84.575 G...	63.675 K	0.03	1867.56

Add to Selected Transitions

---

**Selected transitions**

Transition ^	Description	Rest Frequency ^	Sky Frequency

Remove from Selected Transitions

# Spectral setup in the almaOT (EXAMPLE)

ALMA Observing Tool (Cycle3)

ALMA Observing Tool (Cycle3-Patchtests2) - Project

Select Spectral Lines

Transition Filter: **HCN\***

Frequency Filters: Min 31.3, Max 950

Receiver/Back End Configuration:  Hide unobservable lines,  Filtering unobservable lines

Maximum Upper-state Energy (K): 0 to 100

Molecule Filter / Environment: Show all atoms and molecules

Can't find the transition you're looking for in the offline pool? Find more in the online Splatalogue. [Find More...](#) [Reset Filters](#)

Transitions matching your filter settings:

(double-click column header for primary sort, single-click subsequent columns for secondary sorting. Single clicks will reverse sort order of already selected transitions.)

Transition	Description	Rest Freq...	Sky Freq...	Upper-state E...	Lovas Inte...	Sij
HCN v=0 J=1-0, F=1-1	Hydrogen Cyanide	88.63 GHz	88.63 GHz	4.254 K	9.6	2.967
HCN v=0 J=1-0	Hydrogen Cyanide	88.632 GHz	88.632 G...	4.254 K	17.2	8.911
HCN v=0 J=1-0, F=2-1	Hydrogen Cyanide	88.632 GHz	88.632 G...	4.254 K	17.2	4.946
HCN v=0 J=1-0, F=0-1	Hydrogen Cyanide	88.634 GHz	88.634 G...	4.254 K	6.8	0.989
HCN v=0 J=3-2, F=3-3	Hydrogen Cyanide	265.885 GHz	265.885 ...	25.521 K		0.989
HCN v=0 J=3-2, F=2-1	Hydrogen Cyanide	265.886 GHz	265.886 ...	25.521 K	20	5.347
HCN v=0 J=3-2	Hydrogen Cyanide	265.886 GHz	265.886 ...	25.521 K	20	26.734
HCN v=0 J=3-2, F=3-2	Hydrogen Cyanide	265.886 GHz	265.886 ...	25.521 K	20	7.913
HCN v=0 J=3-2, F=4-3	Hydrogen Cyanide	265.886 GHz	265.886 ...	25.521 K	20	11.466
HCN v=0 J=3-2, F=2-2	Hydrogen Cyanide	265.889 GHz	265.889 ...	25.521 K		0.989
HCN v=0 J=4-3	Hydrogen Cyanide	354.505 GHz	354.505 ...	42.534 K	17.4	35.645
HCN v=0 J=5-4	Hydrogen Cyanide	443.116 GHz	443.116 ...	63.8 K		44.555
HCN v=0 J=7-6	Hydrogen Cyanide	620.304 GHz	620.304 ...	119.088 K		62.379
HCN v=0 J=8-7	Hydrogen Cyanide	708.877 GHz	708.877 ...	153.109 K	48.7	71.293
HCN v=0 J=9-8	Hydrogen Cyanide	797.433 GHz	797.433 ...	191.38 K	55	80.203
HCN v=0 J=10-9	Hydrogen Cyanide	885.971 GHz	885.971 ...	233.899 K	15	89.113

Add to Selected Transitions

Selected transitions

Transition	Description	Rest Frequency	Sky Frequency
------------	-------------	----------------	---------------

Remove from Selected Transitions

Cancel

# Spectral setup in the almaOT (EXAMPLE)

ALMA Observing Tool (Cycle3) Sun Mar 22 14:18 Alvaro Sanchez

ALMA Observing Tool (Cycle3-Patchtests2) - Project  
Select Spectral Lines

File Edit spective 1

**Transition Filter**

HCN\*

Include description

**Frequency Filters**

**ALMA Band**

1 2 3 4 5 6 7 8 9 10

**Sky Frequency (GHz)**

Min 31.3 Max 950

**Receiver/Back End Configuration**

Hide unobservable lines

Filtering unobservable lines

**Maximum Upper-state Energy (K)**

0 20 40 60 80 100 ∞

**Molecule Filter / Environment**

Show all atoms and molecules

Can't find the transition you're looking for in the offline pool? Find more in the online Splatalogue.

Find More...

Reset Filters

**Transitions matching your filter settings:**  
(double-click column header for primary sort, single-click subsequent columns for secondary sorting. Single clicks will reverse sort order of already selected)

Transition ^	Description	Rest Freq...	Sky Freq...	Upper-state E...	Lovas Inte...	Sij
HCN v=0 J=1-0, F=1-1	Hydrogen Cyanide	88.63 GHz	88.63 GHz	4.254 K	9.6	2.967
HCN v=0 J=1-0	Hydrogen Cyanide	88.632 GHz	88.632 G...	4.254 K	17.2	8.911
HCN v=0 J=1-0, F=2-1	Hydrogen Cyanide	88.632 GHz	88.632 G...	4.254 K	17.2	4.946
HCN v=0 J=1-0, F=0-1	Hydrogen Cyanide	88.634 GHz	88.634 G...	4.254 K	6.8	0.989
HCN v=0 J=3-2, F=3-3	Hydrogen Cyanide	265.885 GHz	265.885 ...	25.521 K		0.989
HCN v=0 J=3-2, F=2-1	Hydrogen Cyanide	265.886 GHz	265.886 ...	25.521 K	20	5.347
HCN v=0 J=3-2	Hydrogen Cyanide	265.886 GHz	265.886 ...	25.521 K	20	26.734
HCN v=0 J=3-2, F=3-2	Hydrogen Cyanide	265.886 GHz	265.886 ...	25.521 K	20	7.913
HCN v=0 J=3-2, F=4-3	Hydrogen Cyanide	265.886 GHz	265.886 ...	25.521 K	20	11.466
HCN v=0 J=3-2, F=2-2	Hydrogen Cyanide	265.889 GHz	265.889 ...	25.521 K		0.989
HCN v=0 J=4-3	Hydrogen Cyanide	354.505 GHz	354.505 ...	42.534 K	17.4	35.643
HCN v=0 J=5-4	Hydrogen Cyanide	443.116 GHz	443.116 ...	63.8 K		44.553
HCN v=0 J=7-6	Hydrogen Cyanide	620.304 GHz	620.304 ...	119.088 K		62.379
HCN v=0 J=8-7	Hydrogen Cyanide	708.877 GHz	708.877 ...	153.109 K	48.7	71.293
HCN v=0 J=9-8	Hydrogen Cyanide	797.433 GHz	797.433 ...	191.38 K	55	80.203
HCN v=0 J=10-9	Hydrogen Cyanide	885.971 GHz	885.971 ...	233.899 K	15	89.113

Add to Selected Transitions

**Selected transitions**

Transition ^	Description	Rest Frequency ^	Sky Frequency

Remove from Selected Transitions

Cancel

# Spectral setup in the almaOT (EXAMPLE)

ALMA Observing Tool (Cycle3)

ALMA Observing Tool (Cycle3-Patchtests2) - Project

Select Spectral Lines

File Edit

Transition Filter

HCN\*

Include description

Frequency Filters

ALMA Band

1 2 3 4 5 6 7 8 9 10

Sky Frequency (GHz)

Min 31.3 Max 950

Receiver/Back End Configuration

Hide unobservable lines

Filtering unobservable lines

Maximum Upper-state Energy (K)

0 20 40 60 80 100 ∞

Molecule Filter / Environment

Show all atoms and molecules

Can't find the transition you're looking for in the offline pool? Find more in the online Splatalogue.

Find More...

Reset Filters

Transitions matching your filter settings:

(double-click column header for primary sort, single-click subsequent columns for secondary sorting. Single clicks will reverse sort order of already selected)

Transition ^	Description	Rest Freq...	Sky Freq...	Upper-state E...	Lovas Inte...	Sij
HCN v=0 J=1-0, F=1-1	Hydrogen Cyanide	88.63 GHz	88.63 GHz	4.254 K	9.6	2.967
HCN v=0 J=1-0	Hydrogen Cyanide	88.632 GHz	88.632 G...	4.254 K	17.2	8.911
HCN v=0 J=1-0, F=2-1	Hydrogen Cyanide	88.632 GHz	88.632 G...	4.254 K	17.2	4.946
HCN v=0 J=1-0, F=0-1	Hydrogen Cyanide	88.634 GHz	88.634 G...	4.254 K	6.8	0.989
HCN v=0 J=3-2, F=3-3	Hydrogen Cyanide	265.885 GHz	265.885 ...	25.521 K		0.989
HCN v=0 J=3-2, F=2-1	Hydrogen Cyanide	265.886 GHz	265.886 ...	25.521 K	20	5.347
HCN v=0 J=3-2	Hydrogen Cyanide	265.886 GHz	265.886 ...	25.521 K	20	26.734
HCN v=0 J=3-2, F=3-2	Hydrogen Cyanide	265.886 GHz	265.886 ...	25.521 K	20	7.913
HCN v=0 J=3-2, F=4-3	Hydrogen Cyanide	265.886 GHz	265.886 ...	25.521 K	20	11.466
HCN v=0 J=3-2, F=2-2	Hydrogen Cyanide	265.889 GHz	265.889 ...	25.521 K		0.989
HCN v=0 J=4-3	Hydrogen Cyanide	354.505 GHz	354.505 ...	42.534 K	17.4	35.643
HCN v=0 J=5-4	Hydrogen Cyanide	443.116 GHz	443.116 ...	63.8 K		44.553
HCN v=0 J=7-6	Hydrogen Cyanide	620.304 GHz	620.304 ...	119.088 K		62.379
HCN v=0 J=8-7	Hydrogen Cyanide	708.877 GHz	708.877 ...	153.109 K	48.7	71.293
HCN v=0 J=9-8	Hydrogen Cyanide	797.433 GHz	797.433 ...	191.38 K	55	80.203
HCN v=0 J=10-9	Hydrogen Cyanide	885.971 GHz	885.971 ...	233.899 K	15	89.113

Add to Selected Transitions

Selected transitions

Transition ^	Description	Rest Frequency ^	Sky Frequency
--------------	-------------	------------------	---------------

Remove from Selected Transitions

Cancel

# Spectral setup in the almaOT (EXAMPLE)

ALMA Observing Tool (Cycle3) Sun Mar 22 14:18 Alvaro Sanchez

ALMA Observing Tool (Cycle3-Patchtests2) - Project  
Select Spectral Lines

File Edit

Transition Filter  
HCN\*

Include description

Frequency Filters  
ALMA Band  
Sky Frequency (GHz)  
Min 31.3 Max 950

Receiver/Back End Configuration  
 Hide unobservable lines  
 Filtering unobservable lines

Maximum Upper-state Energy (K)  
0 20 40 60 80 100 ∞

Molecule Filter / Environment  
Show all atoms and molecules

Can't find the transition you're looking for in the offline pool? Find more in the online Splatalogue.  
Find More...  
Reset Filters

Transitions matching your filter settings:  
(double-click column header for primary sort, single-click subsequent columns for secondary sorting. Single clicks will reverse sort order of already selected transitions)

Transition ^	Description	Rest Freq...	Sky Freq...	Upper-state E...	Lovas Inte...	Sij
HCN v=0 J=1-0, F=1-1	Hydrogen Cyanide	88.63 GHz	88.63 GHz	4.254 K	9.6	2.967
HCN v=0 J=1-0	Hydrogen Cyanide	88.632 GHz	88.632 G...	4.254 K	17.2	8.911
HCN v=0 J=1-0, F=2-1	Hydrogen Cyanide	88.632 GHz	88.632 G...	4.254 K	17.2	4.946
HCN v=0 J=1-0, F=0-1	Hydrogen Cyanide	88.634 GHz	88.634 G...	4.254 K	6.8	0.989


Add to Selected Transitions

Selected transitions

Transition ^	Description	Rest Frequency ^	Sky Frequency
HCN v=0 J=1-0	Hydrogen Cyanide	88.632 GHz	88.632 GHz

Remove from Selected Transitions

Cancel



# Spectral setup in the almaOT (EXAMPLE)

ALMA Observing Tool (Cycle3) Sun Mar 22 14:18 Alvaro Sanchez

ALMA Observing Tool (Cycle3-Patchtests2) - Project  
Select Spectral Lines

Transition Filter: **HCO\***

Include description

Frequency Filters

Min: 31.3 Max: 950

Receiver/Back End Configuration

Hide unobservable lines

Filtering unobservable lines

Maximum Upper-state Energy (K): 100

Molecule Filter / Environment

Show: all atoms and molecules

Can't find the transition you're looking for in the offline pool? Find more in the online Splatalogue.

[Find More...](#)

[Reset Filters](#)

Transitions matching your filter settings:  
(double-click column header for primary sort, single-click subsequent columns for secondary sorting. Single clicks will reverse sort order of already selected transitions.)

Transition ^	Description	Rest Freq...	Sky Freq...	Upper-state E...	Lovas Inte...	Sij
HCO 1(0,1)-0(0,0), J=3/2-1/2, F=1-0	Formyl Radical	86.708 GHz	86.708 G...	4.161 K	0.04	1.817
HCO 1(0,1)-0(0,0), J=1/2-1/2, F=1-1	Formyl Radical	86.777 GHz	86.777 G...	4.183 K	0.021	1.817
HCO 1(0,1)-0(0,0), J=1/2-1/2, F=0-1	Formyl Radical	86.806 GHz	86.806 G...	4.185 K	0.015	0.619
HCO+ v=0 1-0	Formylium	89.189 GHz	89.189 G...	4.28 K	10.8	15.21

[Add to Selected Transitions](#)

**Selected transitions**

Transition ^	Description	Rest Frequency ^	Sky Frequency
HCN v=0 J=1-0	Hydrogen Cyanide	88.632 GHz	88.632 GHz

[Remove from Selected Transitions](#)

[Cancel](#)

**HCO\***

# Spectral setup in the almaOT (EXAMPLE)

ALMA Observing Tool (Cycle3) Sun Mar 22 14:19 Alvaro Sanchez

ALMA Observing Tool (Cycle3-Patchtests2) - Project  
Select Spectral Lines

File Edit

**Transition Filter**  
HCO<sup>+</sup>  
 Include description

**Frequency Filters**  
ALMA Band  
1 2 3 4 5 6 7 8 9 10  
Sky Frequency (GHz)  
Min 31.3 Max 950

**Receiver/Back End Configuration**  
 Hide unobservable lines  
 Filtering unobservable lines

**Maximum Upper-state Energy (K)**  
0 20 40 60 80 100 ∞

**Molecule Filter / Environment**  
Show all atoms and molecules

Can't find the transition you're looking for in the offline pool? Find more in the online Splatalogue.  
[Find More...](#)  
[Reset Filters](#)

**Transitions matching your filter settings:**  
(double-click column header for primary sort, single-click subsequent columns for secondary sorting. Single clicks will reverse sort order of already selected transitions.)

Transition ^	Description	Rest Freq...	Sky Freq...	Upper-state E...	Lovas Inte...	Sij
HCO+ v=0 1-0	Formylium	89.189 GHz	89.189 G...	4.28 K	10.8	15.21

[Add to Selected Transitions](#)

**Selected transitions**

Transition ^	Description	Rest Frequency ^	Sky Frequency
HCN v=0 J=1-0	Hydrogen Cyanide	88.632 GHz	88.632 GHz
HCO+ v=0 1-0	Formylium	89.189 GHz	89.189 GHz

[Remove from Selected Transitions](#)

[Cancel](#)



# Spectral setup in the almaOT (EXAMPLE)

ALMA Observing Tool (Cycle3) Sun Mar 22 14:19 Alvaro Sanchez

ALMA Observing Tool (Cycle3-Patchtests2) - Project  
Select Spectral Lines

File Edit

Transition Filter  
HCO\*

Include description

Frequency Filters  
ALMA Band  
Sky Frequency (GHz)  
Min 31.3 Max 950

Receiver/Back End Configuration  
 Hide unobservable lines  
 Filtering unobservable lines

Maximum Upper-state Energy (K)  
0 20 40 60 80 100 ∞

Molecule Filter / Environment  
Show all atoms and molecules

Can't find the transition you're looking for in the offline pool? Find more in the online Splatalogue.  
Find More...  
Reset Filters

Transitions matching your filter settings:  
(double-click column header for primary sort, single-click subsequent columns for secondary sorting. Single clicks will reverse sort order of already selected columns)

Transition ^	Description	Rest Freq...	Sky Freq...	Upper-state E...	Lovas Inte...	Sij $\mu^2$	Cata.
HCO+ v=0 1-0	Formylium	89.189 GHz	89.189 G...	4.28 K	10.8	15.21 D <sup>2</sup>	Offline

Add to Selected Transitions

Selected transitions

Transition ^	Description	Rest Frequency ^	Sky Frequency
HCN v=0 J=1-0	Hydrogen Cyanide	88.632 GHz	88.632 GHz
HCO+ v=0 1-0	Formylium	89.189 GHz	89.189 GHz

Remove from Selected Transitions

Cancel Ok

# Spectral setup in the almaOT (EXAMPLE)

ALMA Observing Tool (Cycle3) Sun Mar 22 14:19 Alvaro Sanchez

ALMA Observing Tool (Cycle3-Patchtests2) - Project

File Edit View Tool Search Help

Project Structure: Unsubmitted Proposal, Project, Proposal, Planned Observations, Science Goals, General, Field Set, Spectral, Calibration, Control, Technical

Editors: Spectral, Spatial, Spectral Setup

In the table below, it is possible to define up to 16 spectral windows, 4 per baseband as long as the total Fraction per baseband is no more than 1. Each baseband is 2GHz wide and can be separately configured i.e. each spectral window can have a different bandwidth and resolution. Note that for bands 3, 4, 6, 7 and 8, it is not possible to put 3 basebands in one sideband and the fourth one in the other.

Spectral Type:  Spectral Line,  Single Continuum,  Spectral Scan

Polarization products desired:  XX,  DUAL,  FULL

Spectral Setup Errors: Baseband-1 : Bandwidth and channel spacing must be set to all spectral windows.

Fraction	Center Freq (Rest)	Center Freq (Sky)	Transition	Bandwidth, Resolution (smoothed)	Spec Avg.	Representative Window
1/2	88.63160 GHz	88.63160 GHz	HCN v=0 J=1...	Please select a correlator mode	1	<input checked="" type="radio"/>
1/2	89.18853 GHz	89.18853 GHz	HCO+ v=0 1-0	Please select a correlator mode	1	<input type="radio"/>

Select Lines to Observe in Baseband-1... Add Delete

Baseband-2

Select Lines to Observe in Baseband-2... Add Delete

Baseband-3

# Spectral setup in the almaOT (EXAMPLE)

ALMA Observing Tool (Cycle3) Sun Mar 22 14:19 Alvaro Sanchez

ALMA Observing Tool (Cycle3-Patchtests2) - Project Perspective 1

File Edit View Tool Search Help

**Project Structure** | **Editors** | Spectral | Spatial | Spectral Setup

Unsubmitted Proposal

- Project
  - Proposal
    - Planned Observations
      - Science Goals
        - General
        - Field Set
        - Spectral
        - Calibration
        - Control
        - Technical

In the table below, it is possible to define up to 16 spectral windows, 4 per baseband as long as the total Fraction per baseband is no more than 1. Each baseband is 2GHz wide and can be separately configured i.e. each spectral window can have a different bandwidth and resolution. Note that for bands 3, 4, 6, 7 and 8, it is not possible to put 3 basebands in one sideband and the fourth one in the other.

Spectral Type ? -

Spectral Line  
 Single Continuum  
 Spectral Scan

Polarization products desired  XX  DUAL  FULL

Spectral Setup Errors

**Baseband-1 : Bandwidth and channel spacing must be set to all spectral windows.**

Spectral Line ? -

Baseband-1 ? -

Fraction	Center Freq (Rest)	Center Freq (Sky)	Transition	Bandwidth, Resolution (smoothed)	Spec Avg.	Representative Window
1/2	88.63160 GHz	88.63160 GHz	HCN v=0 J=1...	58.594 MHz ( 198 km/s), 61.035 kHz ( 0.206 km/s)	1	<input checked="" type="radio"/>
1/2	89.18853 GHz	89.18853 GHz	HCO+ v=0 1-0	58.594 MHz ( 198 km/s), 61.035 kHz ( 0.206 km/s) 117.188 MHz ( 396 km/s), 122.070 kHz ( 0.413 km/s) 234.375 MHz ( 793 km/s), 244.141 kHz ( 0.826 km/s) 468.750 MHz ( 1586 km/s), 488.281 kHz ( 1.652 km/s) 937.500 MHz ( 3171 km/s), 976.563 kHz ( 3.303 km/s)	1	<input type="radio"/>

Select Lines to Observe in Baseband-1...

Baseband-2 ? -

Select Lines to Observe in Baseband-2...

Baseband-3 ? -

# Spectral setup in the almaOT (EXAMPLE)

ALMA Observing Tool (Cycle3)

ALMA Observing Tool (Cycle3-Patchtests2) - Project

File Edit View Tool Search Help

Project Structure

Proposed Program

Unsubmitted Proposal

Project

Proposal

Planned Observations

Science Goals

General

Field Set

Spectral

Calibration

Control

Technical

Editors

Spectral Spatial Spectral Setup

In the table below, it is possible to define up to 16 spectral windows, 4 per baseband as long as the total Fraction per baseband is no more than 1. Each baseband is 2GHz wide and can be separately configured i.e. each spectral window can have a different bandwidth and resolution. Note that for bands 3, 4, 6, 7 and 8, it is not possible to put 3 basebands in one sideband and the fourth one in the other.

Spectral Type

Spectral Type

Spectral Line

Single Continuum

Spectral Scan

Polarization products desired  XX  DUAL  FULL

Spectral Setup Errors

Baseband-1 : Bandwidth and channel spacing must be set to all spectral windows.

Spectral Line

Baseband-1

Fraction	Center Freq (Rest)	Center Freq (Sky)	Transition	Bandwidth, Resolution (smoothed)	Spec Avg.	Representative Window
1/2	88.63160 GHz	88.63160 GHz	HCN v=0 J=1...	58.594 MHz ( 198 km/s), 61.035 kHz ( 0.206 km/s)	1	<input checked="" type="radio"/>
1/2	89.18853 GHz	89.18853 GHz	HCO+ v=0 1-0	58.594 MHz ( 198 km/s), 61.035 kHz ( 0.206 km/s) 117.188 MHz ( 396 km/s), 122.070 kHz ( 0.413 km/s) 234.375 MHz ( 793 km/s), 244.140 kHz ( 0.826 km/s) 468.750 MHz ( 1586 km/s), 488.280 kHz ( 1.652 km/s) 937.500 MHz ( 3171 km/s), 976.563 kHz ( 3.303 km/s)	1	<input type="radio"/>

Select Lines to Observe in Baseband-1... Add

Baseband-2

Select Lines to Observe in Baseband-2...

Baseband-3

bandwidth

resolution

# Spectral setup in the almaOT (EXAMPLE)

The screenshot shows the ALMA Observing Tool (Cycle3) interface. The title bar indicates the application is running on a Mac, with the window title "ALMA Observing Tool (Cycle3-Patchtests2) - Project". The system tray shows the date and time as "Sun Mar 22 14:19" and the user as "Alvaro Sanchez".

The interface is divided into several sections:

- Project Structure:** A tree view on the left showing the project hierarchy: Unsubmitted Proposal, Project, Proposal, Planned Observations, Science Goals, General, Field Set, Spectral, Calibration, Control, and Technical.
- Editors:** A tabbed interface with "Spectral Setup" selected.
- Spectral Setup:** The main configuration area, which includes:
  - Text:** "In the table below, it is possible to define up to 16 spectral windows, 4 per baseband as long as the total Fraction per baseband is no more than 1. Each baseband is 2GHz wide and can be separately configured i.e. each spectral window can have a different bandwidth and resolution. Note that for bands 3, 4, 6, 7 and 8, it is not possible to put 3 basebands in one sideband and the fourth one in the other."
  - Spectral Type:** Radio buttons for "Spectral Line" (selected), "Single Continuum", and "Spectral Scan".
  - Polarization products desired:** Radio buttons for "XX", "DUAL" (selected), and "FULL".
  - Spectral Setup Errors:** A section for reporting errors.
  - Spectral Line:** A section for defining spectral lines, currently showing "Baseband-1".

The "Spectral Line" section for "Baseband-1" contains a table with the following data:

Fraction	Center Freq (Rest)	Center Freq (Sky)	Transition	Bandwidth, Resolution (smoothed)	Spec Avg.	Representative Window
1/2	88.63160 GHz	88.63160 GHz	HCN v=0 J=1...	117.188 MHz( 396 km/s), 122.070 kHz( 0.413 km/s)	1	<input checked="" type="radio"/>
1/2	89.18853 GHz	89.18853 GHz	HCO+ v=0 1-0	117.188 MHz( 394 km/s), 122.070 kHz( 0.410 km/s)	1	<input type="radio"/>

Below the table are buttons for "Select Lines to Observe in Baseband-1...", "Add", and "Delete". Similar sections for "Baseband-2" and "Baseband-3" are visible but currently empty.

# Spectral setup in the almaOT (EXAMPLE)

The screenshot shows the ALMA Observing Tool (Cycle3) interface. The main window is titled "ALMA Observing Tool (Cycle3-Patchtests2) - Project". The "Editors" panel is active, showing the "Spectral Setup" configuration. The "Spectral Type" is set to "Spectral Line". The "Polarization products desired" are set to "DUAL".

In the table below, it is possible to define up to 16 spectral windows, 4 per baseband as long as the total Fraction per baseband is no more than 1. Each baseband is 2GHz wide and can be separately configured i.e. each spectral window can have a different bandwidth and resolution. Note that for bands 3, 4, 6, 7 and 8, it is not possible to put 3 basebands in one sideband and the fourth one in the other.

Spectral Type

Spectral Type  Spectral Line  Single Continuum  Spectral Scan

Polarization products desired  XX  DUAL  FULL

Spectral Setup Errors

Baseband	Fraction	Frequency Range	Line	Resolution	Spec Avg.	Representative Window
1/2					1	<input checked="" type="radio"/>
1/2		89.18853 GHz   89.18853 GHz	H13CO+ v=0 1-0	117.188 MHz ( 394 km/s), 122.070 kHz ( 0.410 km/s)	1	<input type="radio"/>

Select Lines to Observe in Baseband-1... Add Delete

Baseband-2

1(Full)		86.75429 GHz   86.75429 GHz	H13CO+ 1-0	58.94 MHz ( 207 km/s), 30.518 kHz ( 0.105 km/s)	1	<input type="radio"/>
---------	--	-----------------------------	------------	---	---	-----------------------

Select Lines to Observe in Baseband-2... Add Delete

Baseband-3

**the same for H<sup>13</sup>CO<sup>+</sup>**

# Spectral setup in the almaOT (EXAMPLE)

ALMA Observing Tool (Cycle3) Sun Mar 22 14:20 Alvaro Sanchez

ALMA Observing Tool (Cycle3-Patchtests2) - Project

File Edit View Tool Search Help

Project Structure: Unsubmitted Proposal, Project, Proposal, Planned Observations, Science Goals, General, Field Set, Spectral, Calibration, Control, Technical

Editors: Spectral, Spatial, Spectral Setup

In the table below, it is possible to define up to 16 spectral windows, 4 per baseband as long as the total Fraction per baseband is no more than 1. Each baseband is 2GHz wide and can be separately configured i.e. each spectral window can have a different bandwidth and resolution. Note that for bands 3, 4, 6, 7 and 8, it is not possible to put 3 basebands in one sideband and the fourth one in the other.

Spectral Type

Spectral Type:  Spectral Line,  Single Continuum,  Spectral Scan

Polarization products desired:  XX,  DUAL,  FULL

Spectral Setup Errors

Spectral Line

Fraction	Center Freq (Rest)	Center Freq (Sky)	Transition	Bandwidth, Resolution (smoothed)	Spec Avg.	Representative Window
1/2	88.63160 GHz	88.63160 GHz	HCN v=0 J=1...	117.188 MHz( 396 km/s), 122.070 kHz( 0.413 km/s)	1	<input checked="" type="radio"/>
1/2	89.18853 GHz	89.18853 GHz	HCO+ v=0 1-0	117.188 MHz( 394 km/s), 122.070 kHz( 0.410 km/s)	1	<input type="radio"/>

Select Lines to Observe in Baseband-1... Add Delete

Baseband-2

1(Full)	86.75429 GHz	86.75429 GHz	H13CO+ 1-0	58.594 MHz( 707 km/s), 30.518 kHz( 0.105 km/s)	1	<input type="radio"/>
---------	--------------	--------------	------------	--	---	-----------------------

Select Lines to Observe in Baseband-2... Add Delete

Baseband-3

**HCN**  
**HCO<sup>+</sup>**

**H<sup>13</sup>CO<sup>+</sup>**

# Spectral setup in the almaOT (EXAMPLE)

ALMA Observing Tool (Cycle3)

ALMA Observing Tool (Cycle3-Patchtests2) - Project

File Edit View Tool Search Help

Project Structure Editors

Proposal Program **Spectral** Spatial Spectral Setup

Unsubmitted Proposal

- Project
  - Proposal
    - Planned Observations
      - Science Goals
        - General
        - Field Set
        - Spectral
        - Calibration
        - Control
        - Technical

In the table below, it is possible to define up to 16 spectral windows, 4 per baseband as long as the total Fraction per baseband is no more than 1. Each baseband is 2GHz wide and can be separately configured i.e. each spectral window can have a different bandwidth and resolution. Note that for bands 3, 4, 6, 7 and 8, it is not possible to put 3 basebands in one sideband and the fourth one in the other.

Spectral Type [?]

Spectral Line  
 Single Continuum  
 Spectral Scan

Spectral Type

Polarization products desired  XX  DUAL  FULL

Spectral Setup Errors

Spectral Line [?]

Baseband-1

Fraction	Center Freq (Rest)	Center Freq (Sky)	Transition	Bandwidth, Resolution (smoothed)	Spec Avg.	Representative Window
1/2	88.63160 GHz	88.63160 GHz	HCN v=0 J=1...	117.188 MHz( 396 km/s), 122.070 kHz( 0.413 km/s)	1	<input checked="" type="radio"/>
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Baseband-2

1(Full)	86.75429 GHz	86.75429 GHz	H13CO+ 1-0	58.594 MHz( 707 km/s), 30.518 kHz( 0.105 km/s)	1	<input type="radio"/>
---------	--------------	--------------	------------	--	---	-----------------------

Select Lines to Observe in Baseband-2...

Baseband-3



# Spectral setup in the almaOT (EXAMPLE)

ALMA Observing Tool (Cycle3)

ALMA Observing Tool (Cycle3-Patchtests2) - Project

File Edit View Tool Search Help

Project Structure

- Unsubmitted Proposal
  - Project
    - Proposal
      - Planned Observations
        - Science Goals
          - General
          - Field Setup
          - Spectral
          - Calibration
          - Control
          - Technical

Editors

Spectral Spatial Spectral Setup

Visualisation

In the table below, it is possible to define up to 16 spectral windows, 4 per baseband as long as the total Fraction per baseband is no more than 1. Each baseband is 2GHz wide and can be separately configured i.e. each spectral window can have a different bandwidth and resolution. Note that for bands 3, 4, 6, 7 and 8, it is not possible to put 3 basebands in one sideband and the fourth one in the other.

Left/right click to zoom in/out, grab sliding bar to pan  
Note: Moving LO1 here is for experimentation only - actual setup determined by the windows

Observed Frequency

Rest Frequency

Overlays:  Receiver Bands  Transmission  Overlay Lines  DSB Image [Select Lines to Overlay](#)

Water Vapour Column Density:  Automatic Choice  Manual Choice 5.186mm (7th Octile)

Viewport: [Pan to Line](#) [Zoom to Band](#) [Reset](#)

Spectral Type

Spectral Type  Spectral Line  Single Continuum  Spectral Scan

Polarization products desired  XX  DUAL  FULL

# Spectral setup in the almaOT (EXAMPLE)

ALMA Observing Tool (Cycle3)

ALMA Observing Tool (Cycle3-Patchtests2) - Project

File Edit View Tool Search Help

Project Structure

Editors

Spectral Spatial Spectral Setup

Visualisation

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Rest Frequency

Overlays:  Receiver Bands  Transmission  Overlay Lines  DSB Image Select Lines to Overlay

Water Vapour Column Density:  Automatic Choice  Manual Choice 5.186mm (7th Octile)

Viewport: Pan to Line **Zoom to Band** Reset

Spectral Type

Spectral Type:  Spectral Line  Single Continuum  Spectral Scan

Polarization products desired  XX  DUAL  FULL

# Spectral setup in the almaOT (EXAMPLE)

ALMA Observing Tool (Cycle3)

ALMA Observing Tool (Cycle3-Patchtests2) - Project

File Edit View Tool Search Help

Project Structure

- Unsubmitted Proposal
  - Project
    - Proposal
      - Planned Observations
        - Science Goals
          - General
          - Field Set
          - Spectral
          - Calibration
          - Control
          - Technical

Editors

Spectral Spatial Spectral Setup

Visualisation

In the table below, it is possible to define up to 16 spectral windows, 4 per baseband as long as the total Fraction per baseband is no more than 1. Each baseband is 2GHz wide and can be separately configured i.e. each spectral window can have a different bandwidth and resolution. Note that for bands 3, 4, 6, 7 and 8, it is not possible to put 3 basebands in one sideband and the fourth one in the other.

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Water Vapour Column Density:  Automatic Choice  Manual Choice 5.186mm (7th Octile)

Viewport: [Pan to Line](#) [Zoom to Band](#) [Reset](#)

Spectral Type

Spectral Type  Spectral Line  Single Continuum  Spectral Scan

Polarization products desired  XX  DUAL  FULL

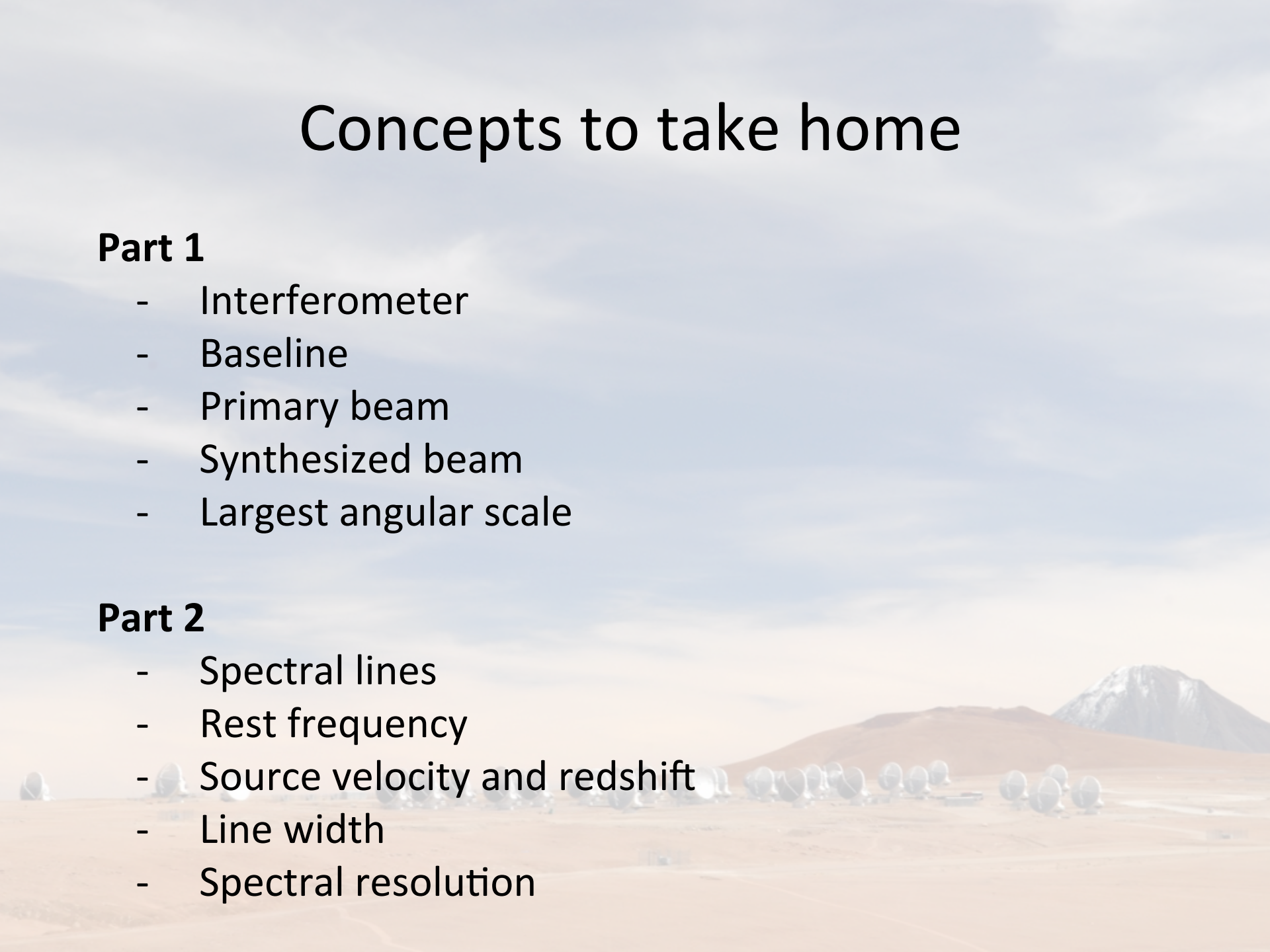
# Concepts to take home

## Part 1

- Interferometer
- Baseline
- Primary beam
- Synthesized beam
- Largest angular scale

## Part 2

- Spectral lines
- Rest frequency
- Source velocity and redshift
- Line width
- Spectral resolution



# Concepts to take home

## Part 1

- Interferometer
- Baseline
- Primary beam
- Synthesized beam
- Largest angular scale

**Questions?**

## Part 2

- Spectral lines
- Rest frequency
- Source velocity and redshift
- Line width
- Spectral resolution

